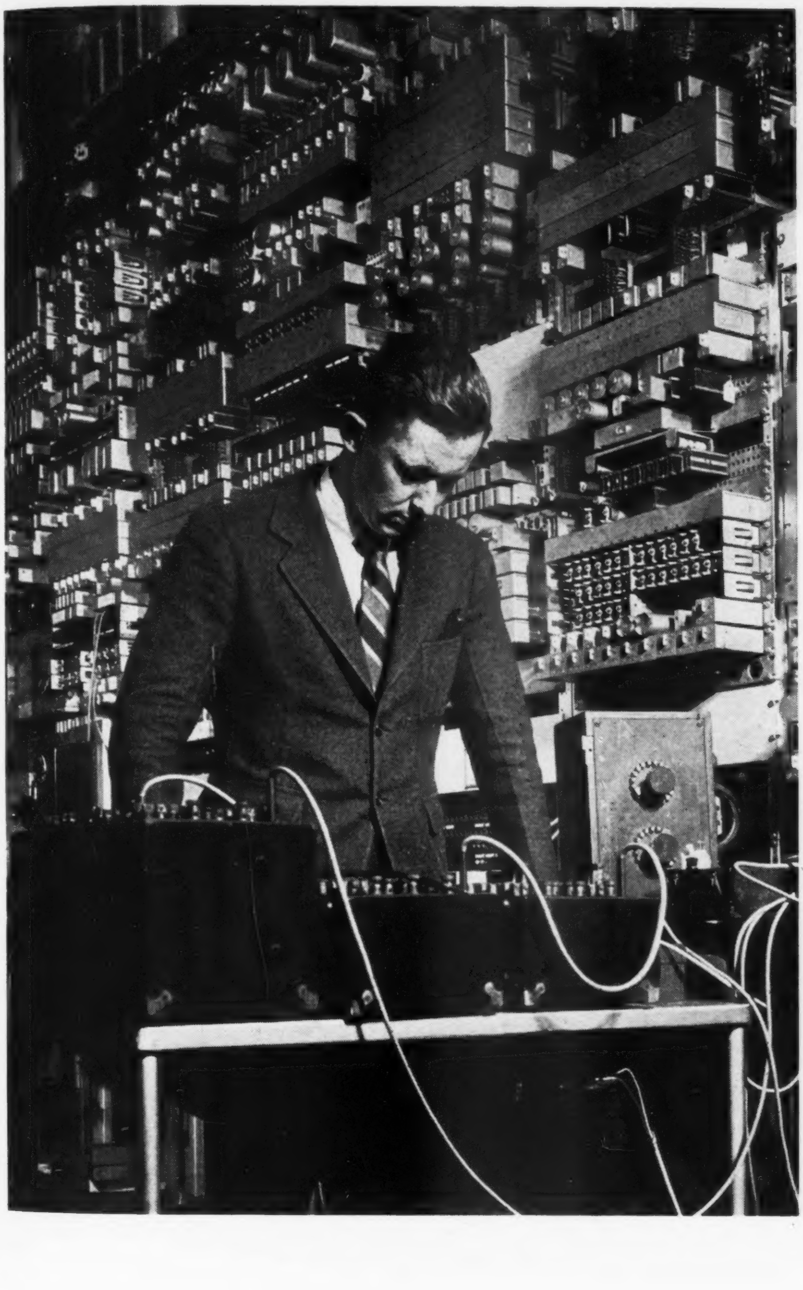
BELL LABORATORIES RECORD

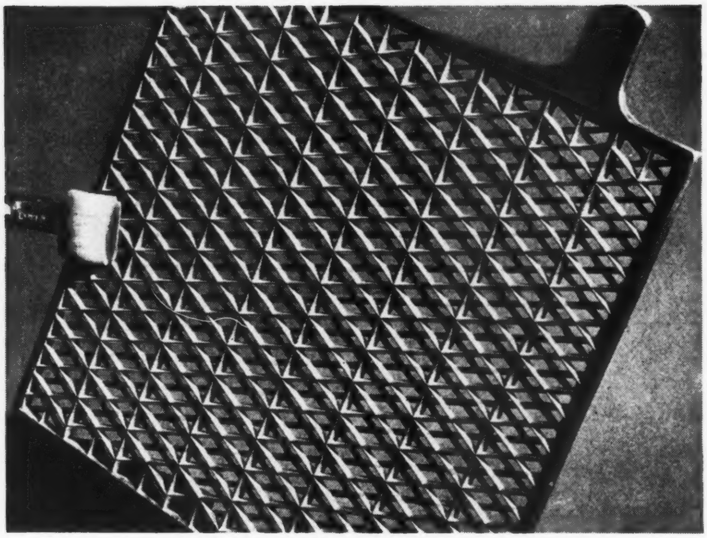


FEBRUARY
1941

VOLUME XIX

NUMBER VI

Range study of twenty-cycle ringing for toll-line circuits.



Batteries in the Telephone Plant

By H. L. MUELLER
Power Equipment Development

FROM its very first days, over sixty years ago, the telephone has used batteries for supplying current to be modulated by the speech waves. In more recent years, batteries have been employed to a much greater extent because of the steady increase in the use of relays, particularly since the adoption of dial switching, which employs relays or other electro-magnetic devices to perform practically all the switching operations. At the beginning, a variety of types of primary cells was employed to provide the necessary current, but within a comparatively few years the lead storage battery came into general use, not only because it permitted charging to replenish its energy, but because its low internal impedance gave better regulation and lessened the coupling between circuits operating in parallel from it. Since then, lead storage batteries have been used universally in telephone power plants, and although they are not manufactured by the Bell System, a great deal of research has been carried on by the Laboratories, and resulting modifications in the battery designs have been made by the manufacturers so as to provide the Bell System with batteries best suited to its needs.

The basic lead cell consists of two flat grids of strong lead alloy in the meshes of which is carried the active material: lead peroxide, PbO_2, on the positive, and spongy lead on the negative. These plates are immersed in a solution of sulphuric acid, H_2SO_4. On discharge, the active material of the positive plate is changed to lead sulphate, $PbSO_4$, and water is given off which dilutes the electrolyte. The spongy lead of the negative plate is also converted to lead sulphate. On charge, the active materials of the

two plates are reconverted to their original form: lead peroxide on the positive plate and spongy lead on the negative plate.

A lead-antimony alloy has been used for the grids of both positive and negative plates, but the form of the plate and the manner of holding the active material have changed. The earlier positive plates were of the Manchester type, shown in Figure 1. The active material is made from corrugated strips of pure lead, rolled up into buttons as shown below the section of plate, and these buttons are forced into the holes of the grid. The corrugations on the strip permit the electrolyte to penetrate to all parts of the button, and thus provide a greater active surface. The negative plate was made up of two plates of square grid work backed with a thin sheet of perforated lead on one side. The active material, chiefly litharge, PbO, is spread into the rectangular grid spaces of each half of the plate, and the two halves are then fastened together. Such a plate is called a box negative; a section of one with a corner turned back is shown in Figure 2.

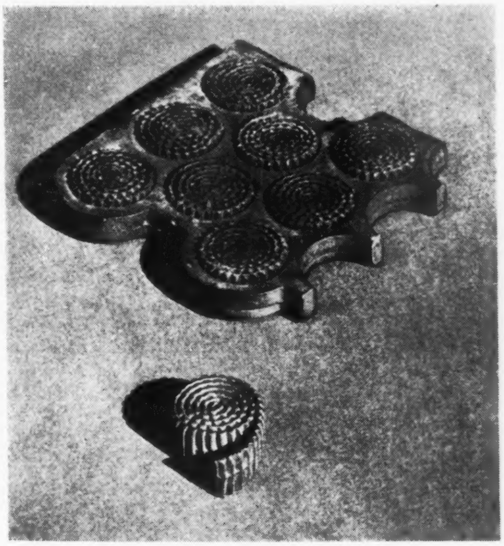


Fig. 1—Section of a Manchester positive plate with one of the lead buttons beneath it

Both positive and negative plates are put through a long electrolytic "forming" process to convert the lead buttons of the positives to lead peroxide, and the litharge of the negatives to spongy lead. After the plates are fully formed, they are assembled with thin wood separators between positive and negative plates, and this assembly is then put in a container to hold the electrolyte. The smaller sizes of cells were of the glass-jar type, while for the larger cells lead-lined wooden tanks were used as shown in Figure 3.

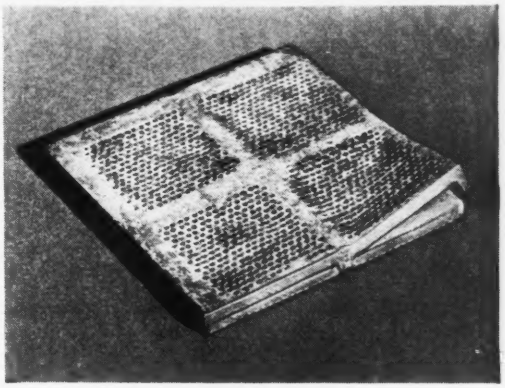


Fig. 2—Section of a box-type negative plate with one corner of facing turned back

Space is generally at a premium in a central office, and Bell System engineers are always looking for ways of securing greater capacity in smaller cells. One of the early changes in storage batteries, therefore, was the adoption of the pasted plate. Grids of this type may have narrow rectangular openings as shown in Figure 4, or diamond-shaped openings as in the illustration at the head of this article, and the active material, in the form of a paste, is filled in these openings. A combination principally of red lead, PbO_4, and litharge is

used for the positive plate, and mainly litharge for the negative. These reduce to lead peroxide and spongy lead after forming, but the forming process is shorter than for Manchester positives and box negatives. At first the assembly of plates was tied together at the bottom by a rubber rod, and hung from a cover plate by the terminals. An early modification was the addition of thin slotted rubber envelopes slipped over the positive plates from each side to hold the active material in place. Wood separators were also used, but the softer condition of the active material on the positive plate needed added support to hold it in place during charge, when the evolved gases create a steady wash of electrolyte upward along the surface. These pasted plates permitted considerably larger capacity cells to be mounted in glass jars and charged at the factory.

A minor improvement made about this time was the addition of a cage containing colored pellets to give an indication of the state of charge of the battery. One pellet is white and one red, and their specific gravity is adjusted so that the white pellet sinks at approximately ⅓ discharge, and the red pellet, at ⅔ discharge. As the cell is recharged, the pellets float as the charge reaches the ⅓ and ⅔ state. These give easy indication to the maintenance force as to the approximate state of charge of the cells, and permit any pronounced irregularities to be readily seen.

During charge, and particularly toward the end of the charging period, oxygen gas is given off at the positive plate and hydrogen gas at

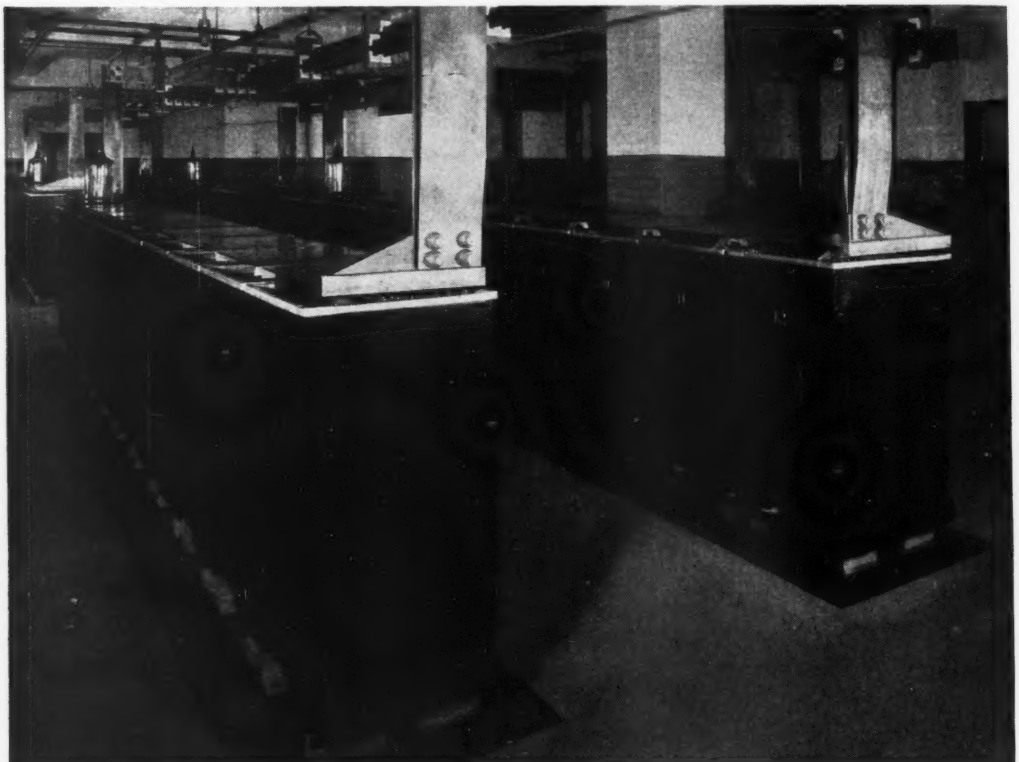


Fig. 3—An installation of lead-lined tanks, such as are used for the larger batteries

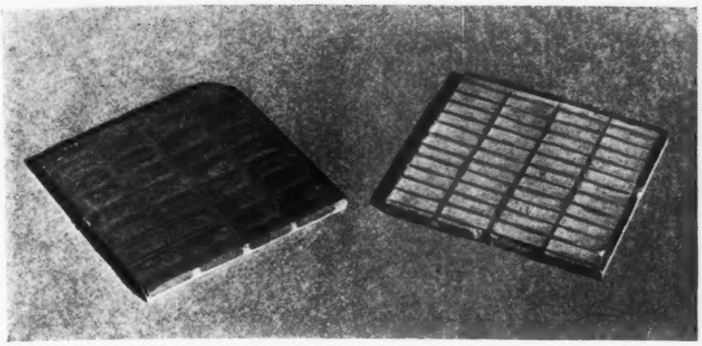


Fig. 4—Sections of negative and positive plates of the pasted type provided with narrow rectangular openings

the negative plate, and these two gases—or the hydrogen alone with the oxygen of the atmosphere—form an explosive mixture. In the open air around the cells, the quantity of hydrogen present is too small to be explosive, but with the new tightly closed glass jar it seemed worth while to take steps to avoid an explosion within a cell that might be caused by a small spark of static electricity, perhaps generated by the attendant in walking around the battery. To minimize this hazard, the combined funnel and vent plug shown in Figure 5 was developed. The lower end of this device is very close to the tops of the separators, and is therefore always immersed in the electrolyte. The gas, rising through the electrolyte, enters the space between the surface of the electrolyte and the cover, and escapes through vent holes just below a hard-rubber ring that deflects the gas outward away from the mouth of the funnel. If a spark should be formed as the attendant touches the top of the funnel to add water to the battery or measure the specific gravity of the solution, no explosion would occur because there is insufficient gas within the funnel to form an explosive mixture. Since the funnel tip is always immersed in the electrolyte and telephone batteries are grounded, the discharge is conducted to ground without a spark occurring within the cell.

Extended experience with batteries in the field indicated that better life could be secured if the group of plates could be more firmly held together. This need has been met in two ways by different manufacturers. One employs heavily reinforced outside negative plates held together by hard-rubber tie rods as shown in Figure 6. The other employs a strong moulded-glass jar, and the plates are held together by wedges between the jar and the outer negative plates. Glass jars of the blown type are not strong enough to withstand this

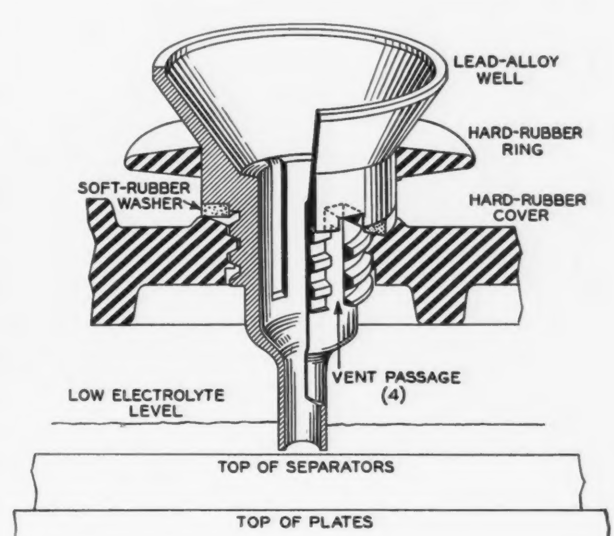


Fig. 5—Combined funnel and vent plug designed for sealed-glass storage cells

wedging pressure, and for this reason moulded glass was used. Such a cell is shown in Figure 7.

In earlier practice, the batteries were operated on a charge and discharge basis; they were usually charged during the day, and allowed to partially discharge at night. Under these conditions the life of the battery is usually determined by the washing away of the active material from the positive plate. In more recent years, however, the practice has been to "float" the batteries. A generator, with accurately regulated voltage, is

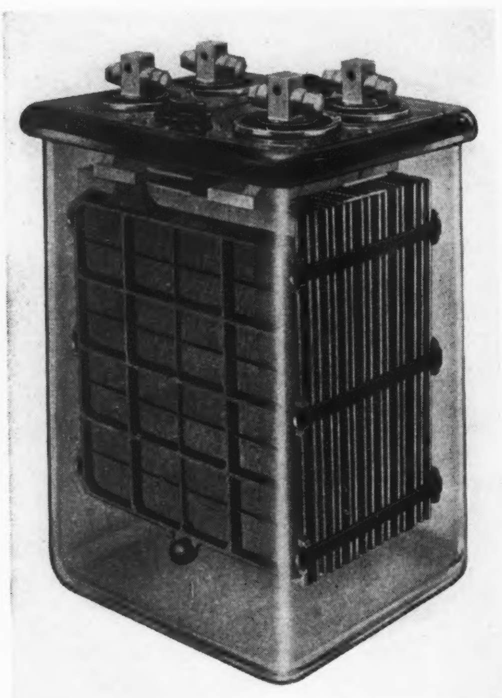


Fig. 6—One recent sealed-jar cell uses reinforced outer negative plates held together by hard-rubber tie rods

connected across the battery all the time. It directly supplies all the normal office load, and a small trickle charge into the battery to replace internal losses so as to maintain it at full charge all the time. Only in case of failure of the commercial power supply does the battery carry the load. Since it is during the periods of charging that the active material of the positive plate is washed away, "floating" operation results in a longer life for the battery. With floating, failure generally results from a gradual wasting away of the grid structure of the plate. It was obvious, therefore, that longer life could be secured by making a heavier grid structure, and a line of batteries having thick-plate grids was developed. The use of these thick-plate grids increased the life of the batteries about forty per cent. One of these thicker positive grids is shown beside a thinner one in Figure 9.

The limiting factor in the size of glass-jar batteries is the strength of the glass container. Larger batteries have used lead-lined wooden tanks, which required that the plates be assembled in the central office, and this requires a lot of additional work

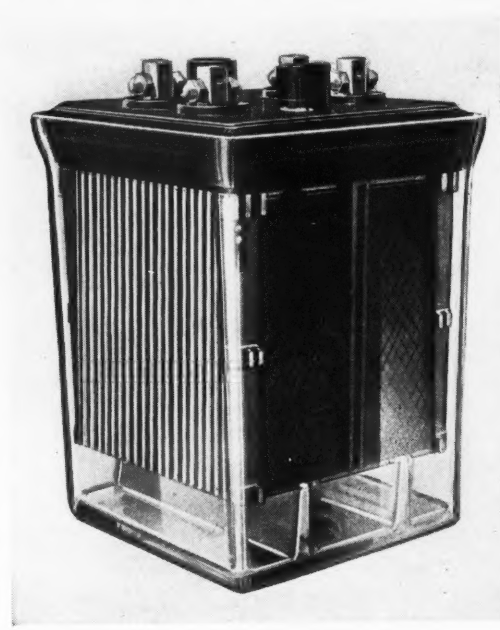


Fig. 7—Another type of cell uses reinforced outside negative plates that are wedged in a moulded-glass jar

Fig. 8—*An installation of new hard-rubber tanks for large-capacity plants*

and charging before the battery is ready for service. A recent change that permits the use of larger capacities in factory-assembled cells is the adoption of hard-rubber tanks as shown in Figure 8. These have a sealed rubber cover and thus permit larger sizes with factory assembly. Sealed rubber jars are also being used for the smaller cells that have previously used glass jars. With rubber cells, both in the smaller and larger sizes, two methods are employed—each by a different manufacturer—to secure freedom from explosions. In one, a rubber hood is placed over the plates just above the separators, and a vent is carried from the highest, or central, part of it through the cover and up a few inches above it to carry away the gas that collects. All the gas rising from the electrolyte is gathered by this hood and conducted to the air and thus none collects between the hood and the sealed cover. Should an explosion occur, it would be only of the small amount of gas in the vent, and would result merely in a small "pop." The other method employs a perforated rubber baffle over the top of the plates, and the space between the baffle and the sealed top is filled with smooth glass crystals. A vent pipe is carried through the top of the cell to allow the gas to escape, while a filling funnel runs down through the perforated baffle to the top of the separators. The function of the glass crystals is to cool the gas, if it should

be ignited, below the burning temperature. Both methods have been found to reduce explosions to harmless "pops."

Since these rubber cells are not transparent, they are provided with "level indicators" to indicate the height of the electrolyte. These are small floats contained in tubes running through the cover and down to the separators.

One of the promising recent developments in batteries is the lead-calcium plate, already described in the RECORD.* The antimony in the previous plates tended to leach out and thus weaken the grid structure, which has affected the life of the cells, particularly under "float" operation. Calcium is free from both of these objections, and field and laboratory tests are now being made to ascertain the performance of the lead-calcium cells under the usual "floating" operations.

*RECORD, *September*, 1937, *p.* 12.

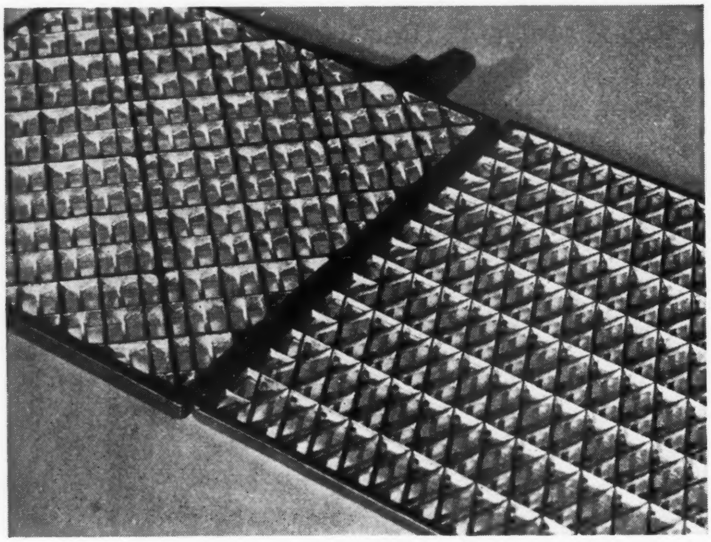


Fig. 9—The new positive grids for floating service, shown at the left, are thicker and have heavier cross-members

Dust-Storm Static

By M. T. DOW
Transmission Engineering

WHEN dense clouds of wind-blown dust blanket a dust bowl, electrical phenomena occur which are often of a surprising nature. Press reports in the wake of these storms have described such effects as corona on radio antenna lead-ins and fences, failure of automobile ignition systems, interference with airplane communications, flashovers on power systems at insulators and lightning arrestors, and even the electrocution of wheat in the fields. These phenomena are of direct concern also to communication companies and the possibility of their occurrence must be taken into consideration in the design of open-wire telephone circuits. If appropriate preventive measures are not provided, severe noise disturbances may be caused on important circuits during dust storms. These disturbances cover a broad frequency band and may affect both voice-frequency and carrier-frequency circuits. In regions where these storms occur frequently, "dust static" may be a more important consideration in determining maximum repeater spacings for open-wire telephone systems than the more usual atmospheric disturbances that are the result of lightning.

No theory has as yet been evolved which explains satisfactorily the mechanism responsible for "dust static." It seems evident, however, that the flying dust particles become electrically charged by friction with one another, the air, and other surface materials of the earth and it is known that their presence greatly increases the potential gradient of the atmosphere. Evidence obtained from field tests and theoretical studies indicate that the noise-producing mechanism is an electrical discharge from the

The photograph above is reproduced through the courtesy of the Oklahoma Publishing Company.

wites to the atmosphere which takes place as the electrified dust particles enter the region of high potential gradient immediately surrounding the line conductors.

The noise produced in telephone circuits by a dust storm is characterized by a hissing sound which

Fig. 1—Voltage recorder with which studies of dust-storm static are made. Miss E. M. Rentrop is operating the apparatus

builds up gradually in intensity as the severity of the storm increases. In the absence of lightning the noise eventually reaches a more or less steady level which may persist for hours. The hissing noise is accompanied by a rise in potential to ground of the line wires and the intensity of the noise correlates with the latter to some extent. Tests have shown, however, that the noise persists even though the line conductors are at ground potential. Noise has been found to be lower, by as much as 10 to 20 db, on pairs which occupy inner pin positions than on those located at the outer ends of a crossarm.

When the effects of lightning are superimposed on those of dust static, variations in the noise and the voltage or current to ground become very rapid and erratic. Sometimes after a gradual build-up the noise increases suddenly 20 to 30 db and then gradually decreases. At other times, after a particular magnitude has been reached through gradual increases of the disturbances, a sudden drop occurs, sometimes to zero.

It is important in regions where these disturbances occur that a direct-current path be provided from line wires to ground. Without such a path the high potential set up on the conductors may cause intermittent breaking down of the line protectors and superimpose a popping noise on the relatively steady hissing sound. Under severe conditions the charges on the wires may build up rapidly enough to cause protector breakdowns at the rate of 300 times per minute. If the line protectors were removed, the potential to ground might reach surprising proportions. In one such test it built up to 15,000 volts, at which value flashover occurred across the gap between the terminal of the line and the ground bus. These high-potential discharges are not dangerous, however, because the power that is dissipated is very small.

When a direct-current path is provided as much as several milliamperes may flow continuously from the line wires to ground. Tests have shown that the magnitude of this current is more or less independent of the resistance of the drainage circuit over

a range from 0 to 100,000 ohms, which indicates that the discharge source is of very high internal impedance.

Snow and sleet storms may also cause noise in telephone circuits which is generally similar in character to that observed during dust storms. The term "precipitation static" is used to identify both types of noise.

Field tests of the effects of precipitation static have been carried out by the Laboratories in several locations in connection with the development of the new open-wire carrier systems. A number of tests were made on the Fourth Transcontinental Line and on the lines between Trinidad and Amarillo, which traverse a region that is probably the most severely affected by storms of this type.

The field tests indicate that satisfactory drainage paths to ground, which are needed to prevent the intermittent breakdown of protectors during storms, may be provided either through special drainage apparatus or through equipment normally used for other purposes, such as ground-return alarm and control circuits, simplex telegraph or other direct-current telegraph connections.

The Laboratories studies have also yielded data from which it was possible to determine operating levels and repeater spacings for the new open-wire carrier systems that would suitably limit the effects of the hiss of precipitation static. Thus satisfactory operation of these systems has been secured during both good and stormy weather. In regions where precipitation static occurs, the repeaters must be spaced much more closely than in other parts of the country.

G. A. Campbell Awarded Edison Medal

The Edison Medal for 1940 *has been awarded by the American Institute of Electrical Engineers to George Ashley Campbell, who retired from the Laboratories in* 1935, "*in recognition of his distinction as a scientist and inventor and for his outstanding original contributions to the theory and application of electric circuits and apparatus.*" *Among the eminent engineers and scientists who have been recipients of the medal are Elihu Thomson, George Westinghouse, Alexander Graham Bell, John J. Carty, Michael I. Pupin, Robert A. Millikan, Frank B. Jewett and Bancroft Gherardi.*

The 2B Carrier Pilot Channel

By D. M. TERRY
Transmission Development

WITH the early open-wire carrier systems, the variations in line loss that occur with changes in weather conditions were offset by manual adjustments of gain at repeater stations or terminals. Meters were employed to indicate the level of the transmitted signal at various points, and by frequent attention to them and careful coördination of the adjustment made at various points along the line, the maintenance force could hold the variation in gain to about 3.5 db either way from normal. This regulation was considerably improved and maintenance procedures simplified some years ago by the development of the 2A carrier pilot channel.* With that system, the gain corrections were made automatically, and the variation could be held to ±2 db. In connection with the development of the C5 carrier system,† a new regulating system known as the 2B carrier pilot channel was developed.

This new system, although similar in principle to the 2A, uses improved circuits and equipment, and will hold the variation in transmission to about ±1 db. Along with this improvement in performance, there has been simplification in the design that results in a marked saving in equipment and space and greatly reduced first cost and maintenance.

A pilot current of suitable frequency is transmitted between terminals in each direction. The amplitude of this pilot current as received at each repeater and at the distant terminal is used as an indication of the changes in line loss over the corresponding section of the line. When the received pilot current departs from its normal level, automatic equipment operates to add or take out local attenuation to restore the pilot current at the output of the repeater or receiving amplifier to its normal level. By this change in attenuation, the three carrier speech bands, transmitted over the same path as the pilot current, are likewise adjusted to normal levels. The frequency of the pilot current is so selected that it lies adjacent to the central channel band for each direction, as shown in Figure 1, and its normal value at the output of the repeater or receiving amplifier is 8 db above reference power of one milliwatt.

The attenuation of the open-wire line

*Record, *October*, 1934, *p.* 49.
†Record, *August*, 1940, *p.* 354.

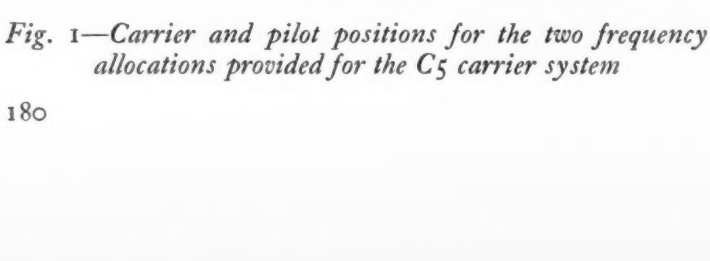


Fig. 1—Carrier and pilot positions for the two frequency allocations provided for the C5 carrier system

increases with frequency, and an equalizer network with a slope equal but opposite to that of the line, and in amount sufficient to equalize the maximum wet-weather attenuation of a line section, is inserted in the incoming circuit at each repeater and receiving terminal. Normally, with the line not exhibiting its maximum attenuation, local artificial line is added to build out the line attenuation to the maximum value for which equalization is designed. An overall flat loss frequency characteristic is thus obtained. Since the changes in line loss themselves increase with frequency, the attenuation correction must be graded correspondingly, as shown in Figure 2. With the earlier 2A pilot channel, regulation is obtained by inserting or removing units of artificial line in steps of about ¼ db, while with the 2B pilot channel, the regulation is smooth. The gain is changed by a motor that drives an air condenser connected as a potential divider across artificial line units. A schematic of the circuit elements is shown in Figure 3.

The pilot current, along with the speech sideband currents, enters the artificial line units at the left of the figure after passing through the equalizer. The actual attenuation afforded by these artificial line units is determined by the position of the rotor of the regulating condenser, which interleaves successively with four stator sections. These stator sections bridge across the four line units as shown. The condenser operates as a smoothly changing potential divider. The voltage thus tapped from the artificial line units is made effective by being impressed across the high-impedance input of the regulating amplifier, which is arranged with a stabilizing feedback circuit. The output of this one-tube buffer amplifier is supplied to the line amplifier, if at a repeater, or to the receiving amplifier, if at a terminal. It is at the output of this second or main amplifier that the pilot current is tapped off to control the regulation. The amount of line current taken is kept very small by using a bridging circuit of very high impedance. The pilot current is then filtered

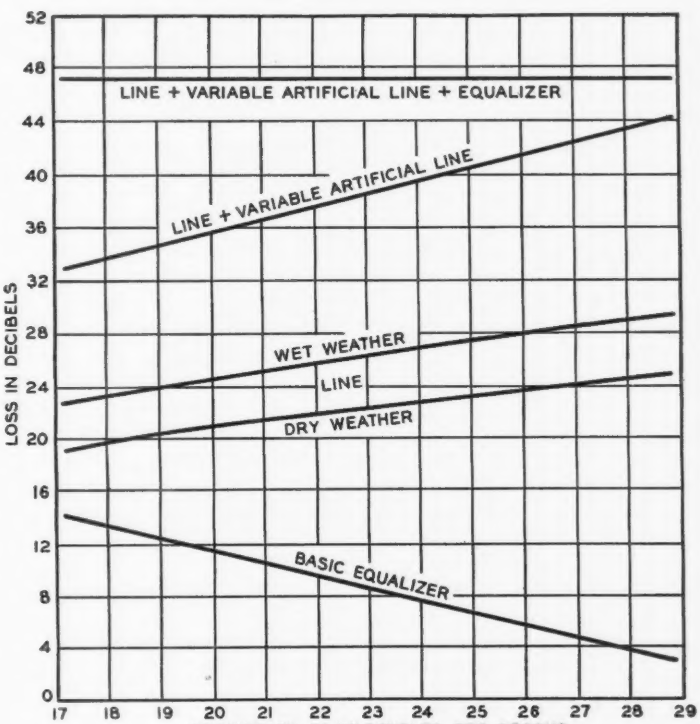


Fig. 2—Frequency-loss diagram for upper frequency band of the C5 carrier system indicating function of equalizer and artificial line in making attenuation corrections

out through a narrow-band filter, and rectified by a copper oxide varistor. The resulting direct current flows through the armatures of two "Sensitrol" relays. The upper relay initiates regulation through contacts when the pilot current departs from normal by ±0.5 db. The lower relay is used for alarm and suspension of regulation by effecting contacts when the pilot current suddenly falls from its normal value by 5 db, or more, or suddenly increases by 3 db, or more, from the normal level.

When the pilot current changes by 0.5 db in either direction, the upper relay operates relay A or B depending upon the direction of current change. These relays effect contacts which drive the regulating motor in the proper direction to return the pilot current to its normal level. A reduction gearing is employed between the motor and the regulating condenser so that the attenuation correction will not take place too fast. A maximum of approximately 32 db of regulation is provided. The change in regulation, however, is effected through successive operating periods of the motor until the pilot current is restored to the normal operating region. These periods are timed by the slow-operate pulse relay which is operated from the A or B relay.

This pulse relay is one of three slow-action mercury relays. When the relay is energized, a mercury column is displaced by a solenoid-operated plunger, and contact is produced when the mercury reaches a certain height, but its rise is delayed by the slow release of trapped gas through a ceramic orifice. The closing of the contact of the pulse relay operates restoring mechanisms on the Sensitrol relays, which pull the pointers off contact to central positions. This releases the A or B relay previously operated, which in turn releases the

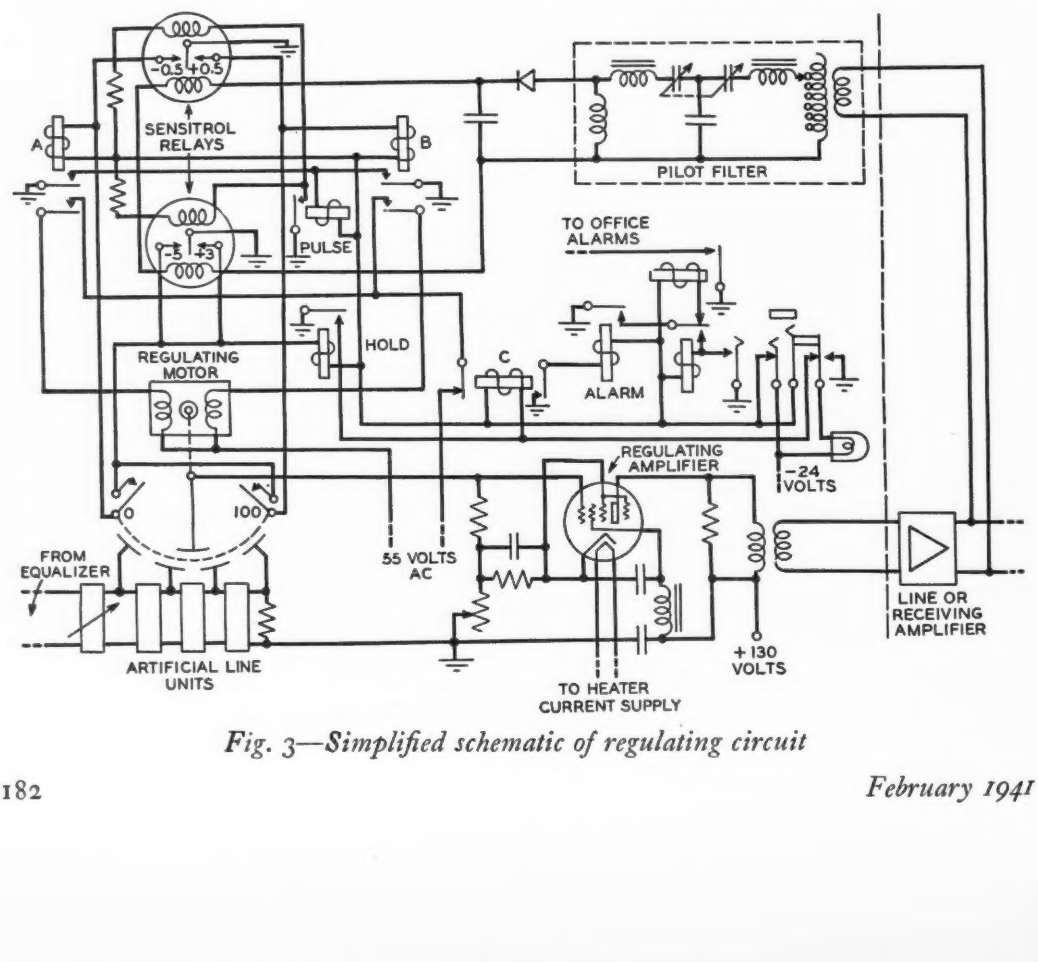


Fig. 3—Simplified schematic of regulating circuit

pulse relay. The restoring mechanism of the Sensitrol relays is then released, allowing the pointers to re-contact or take up any new position. Pulsing will continue until sufficient gain correction has been made.

One of the desirable features of the Sensitrol relay is the provision of more than the usual contact pressure for relays operating on such small current. This added pressure is secured by small permanent magnets at the stationary contacts, which exert a pulling force on an iron armature attached to the bottom of the pointer when the pointer comes within ⅛ inch of contact. Operation of the restoring mechanism is thus necessary to lift the pointer off contact.

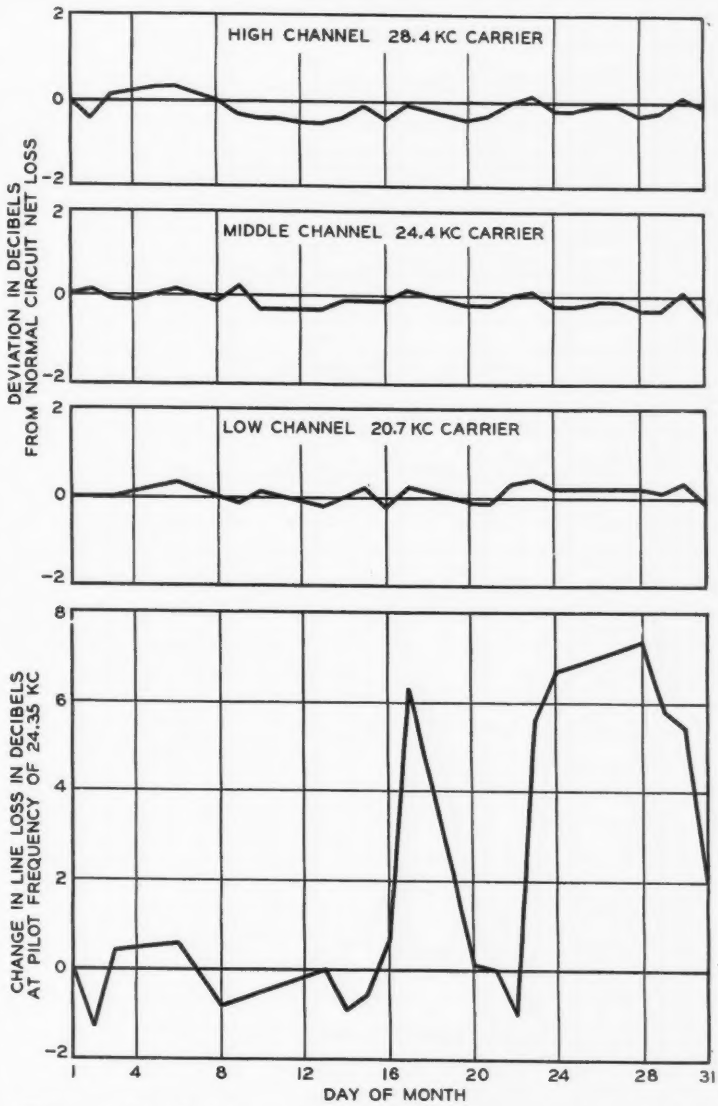
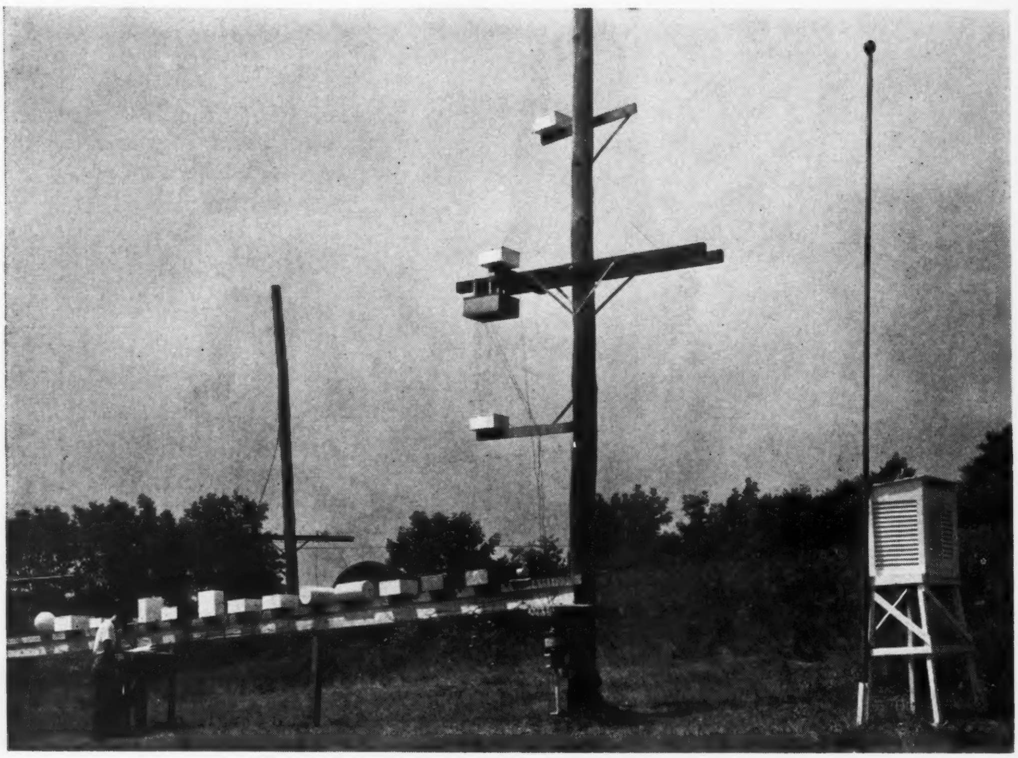


Fig. 4—Regulation maintained for a one-month period by the 2B pilot channel over a system with one repeater

When a sudden large change in energy occurs, the lower Sensitrol relay operates. This relay is used for alarm purposes, and its contacts, when made, operate the "HOLD" mercury delay relay. This latter relay is arranged to operate fast but to give a slow release so that under the alarm-pulsing conditions continuous contact is provided to hold relay c operated. Relay c opens the a-c circuit of the motor, stopping further regulation, and also energizes the alarm delay relay. A continuous energization of this latter relay for approximately 25 seconds is necessary before its contact takes place, when it brings in an audible alarm. This delay is incorporated to prevent momentary changes in line levels, even though of large magnitude, from bringing in an alarm. The principal purpose of this alarm is to call attention to open-line circuits. Additional alarms are provided on the regulating condenser to call attention if an end position is reached, since it

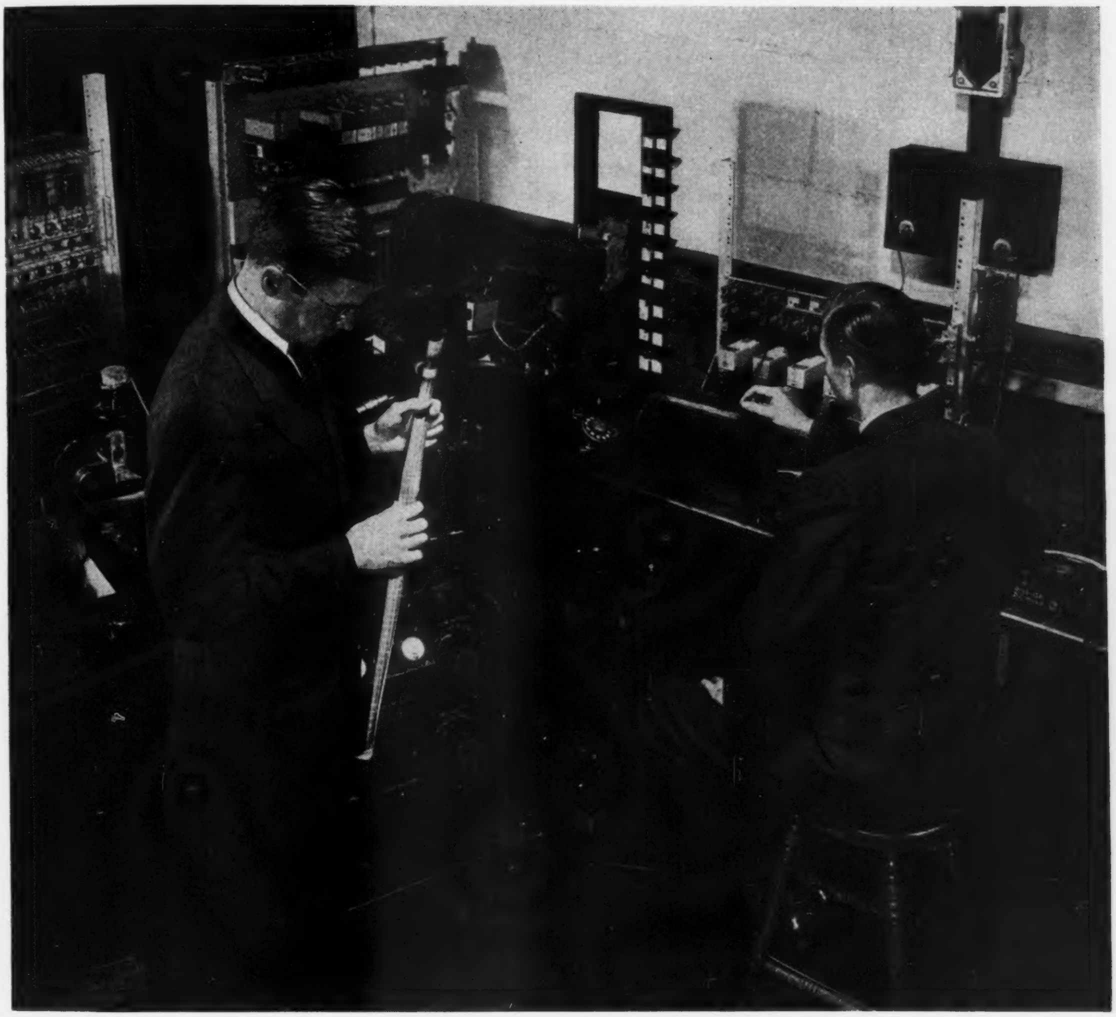
would stop further regulation in that particular direction. All alarms are automatically self-restoring.

The regulation provided by the 2B carrier pilot channel over a typical system with one repeater is shown in Figure 4. Although wide changes of temperature and weather may take place, the overall transmission will, in general, be maintained with a variation in transmission of less than 1 db. In addition to providing better regulation than the 2A pilot channel, the 2B pilot channel requires considerably less space, a seven-inch panel instead of nearly a full bay for the 2A. This has already been pointed out in the RECORD for May, 1939, pages 288 and 289, where photographs were given of both the pilot channels.



To determine how hot apparatus may become out of doors, this array of steel boxes has been set up at the Chesterfield laboratory. The effect of the shape of the boxes, various orientations relative to the sun, paints of different colors and insulation inside the boxes are being tested. Temperatures are measured with thermocouples which are located in the boxes. The slotted box at the right is a shelter in which the air temperature is measured. An anemometer at the top of the pole determines the wind velocity. G. E. Hadley is making the measurements

NEWS AND PICTURES OF THE MONTH

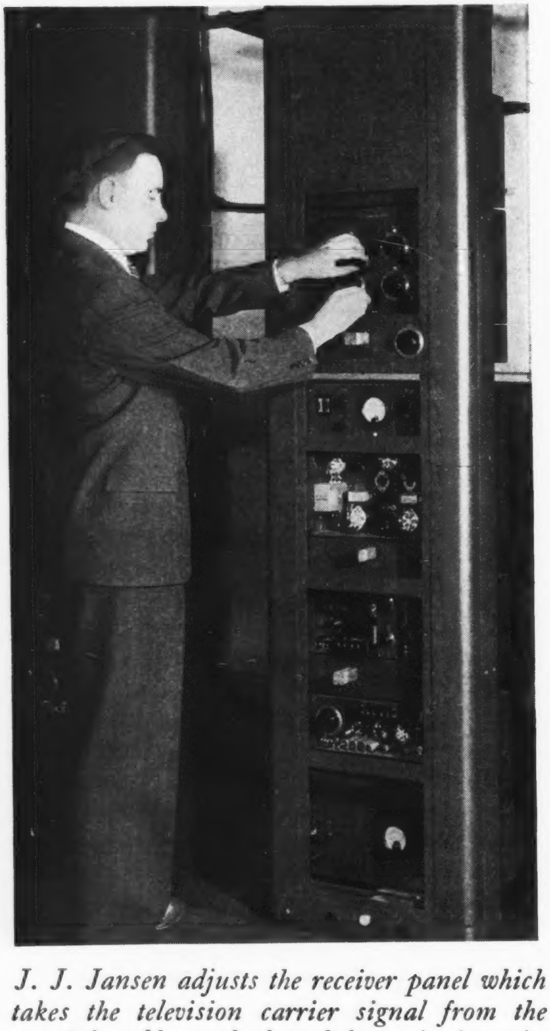


Experimental tests of circuits in the crossbar system. The engineers shown are F. N. Rolf (left) and D. T. Hareid

News of the Month

Television Demonstration for I.R.E.

Television over an all-wire circuit 200 miles long was demonstrated on January 11 to over 550 members and guests of the Institute of Radio Engineers when a program taken from motion-picture films was transmitted from the Graybar-Varick building of the Laboratories in New York City over the coaxial cable to Philadelphia and back to the Pennsylvania Hotel. The demonstration was arranged as a feature of the Winter Convention of the Institute and allowed observers to make a comparison of a scene transmitted over the loop of cable with the same scene locally transmitted across a few miles in New York City. The scenes were reproduced on a special television receiver-tube developed in the Laboratories; and when viewed from the usual distance of five or six feet the difference between local and long-distance cable transmission was imperceptible.



J. J. Jansen adjusts the receiver panel which takes the television carrier signal from the coaxial cable and demodulates it into its original video form

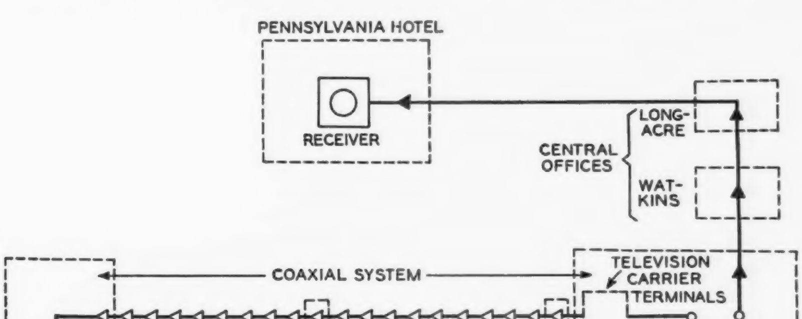
Both the cathode-ray rube and the transmitter which were used in the demonstration were developed primarily as testing instruments for use in the study of television transmission, since the Bell System interest in television is primarily in providing interconnecting facilities for transmitting programs from point to point in the same general way as it provides such facilities for sound programs. So as to have a wide range of subjects available for transmission studies, motion-picture films are used rather than direct pick-up from a television studio.

While the distance involved in this demonstration was not the longest that had been used—the 1927 demonstration between New York and Washington required over 300 miles of long-distance lines—the frequency band transmitted was 2,700,000 cycles wide compared to the 20,000 cycles of that date. In the direct transmission from the film scanner in the Graybar-Varick building to the Pennsylvania Hotel, there was transmitted the entire frequency range of the complex video signal, 4,000,000 cycles. Despite, however, this difference in range, motion-picture scenes under the two conditions of transmission were generally agreed to be imperceptibly different.

The demonstration was under the general supervision of J. F. Wentz, assisted by L. W. Morrison; D. S. Barlow equalized the video lines from the Graybar-Varick building to the Pennsylvania Hotel; A. R. Kolding han-

dled the operating controls at the Pennsylvania Hotel; J. R. Brady and R. J. Shank manned the apparatus at the Pennsylvania Hotel; J. J. Jansen, H. C. Hey and A. F. Mott handled the switching arrangements at the carrier terminal in the Graybar-Varick building; E. G. Morton and F. A. Janiszewski were at the 32 Sixth Avenue coaxial terminal; M. M. Bower made the necessary arrangements with the Long Lines Department to maintain the circuit at Princeton and Philadelphia in case of trouble; and L. H. Morris made certain adjustments along the line during the two-day period of demonstrations.

Technical papers on the system and apparatus were presented before the Television Theory and Measurements session of the Institute: by M. E. Strieby of the A. T. & T. and C. L. Weis, *Some Factors Affecting Television Transmission;* by A. G. Jensen, *Film Scanner for Use in Television Transmission Tests;* and by R. E. Graham and F. W. Reynolds, *A Simple Optical Method for the Synthesis and Evaluation of Television Images*. Other papers presented before other sessions of the convention were *Measurements of the Delay and Direction of Arrival of Echoes from Nearby Short-Wave Transmitters* by K. G. Jansky and C. F. Edwards; *After-Acceleration and Deflection of a Cathode-Ray Tube* by J. R. Pierce; and *Program-Operated Level-Governing Amplifier* by W. L. Black and N. C. Norman.



Schematic of transmission circuits used in the television demonstration for the Institute of Radio Engineers

Colloquium

At the December 16 meeting of the Colloquium, Dr. Hugh S. Taylor of Princeton University discussed *The Characteristics of Iron, Tungsten and Osmium Catalysts as Revealed by Nitrogen Isotope Exchange Reactions*. The capacity of iron, tungsten and osmium metals to take up nitrogen on their surfaces has been investigated by studying the rate of interaction of light and heavy nitrogen molecules. The results have been correlated with studies of ammonia synthesis to indicate clearly what are the important factors in these industrially important operations.

On December 30 Dr. Cornelius P. Rhoads, recently appointed director of the Memorial Hospital of New York, spoke on recent striking developments in a theory of the dietary basis of cancer.

Eta Kappa Nu Honors Stuart C. Hight

For the second successive year a member of the Laboratories has been recognized by Eta Kappa Nu, honorary electrical engineering fraternity, as outstanding in his profession. For 1939 Larned A. Meacham of Circuit Research received the award of Outstanding Young Electrical Engineer, and for 1940 Stuart C. Hight has been honorably mentioned. The award, which is for electrical engineers graduated not more than ten years, and less than thirty-five years of age, was inaugurated in 1936 and all of the candidate's activities—technical, civic, social and cultural—are considered.

Mr. Hight joined the Laboratories in 1930 after he had received the B.S. degree in Electrical Engineering from the University of California. He has been engaged here with the radio research group in investigations of quartz-crystal oscillators and their associated circuits. These studies have resulted

in the development of more precise methods for controlling the effects of temperature changes in the frequency of crystal oscillators. He holds several patents and was directly responsible for the discovery of six of the present known cuts for quartz crystals

S. C. Hight, honorably mentioned for Eta Kappa Nu's 1940 *award of Outstanding Young Electrical Engineer*

which give zero temperature coefficient of frequency. Mr. Hight has published several articles and has presented papers before the Institute of Radio Engineers and the Acoustical Society of America.

In 1935 Mr. Hight obtained his M.A. degree in Physics from Columbia University. He is a member of the I.R.E., A.I.E.E., the American Physical Society, and the American Radio Relay League. In 1939 he helped organize the Bell Laboratories Sailing Club and was its first commodore. He has also contributed effectively to the work of the Sea Scouts in South Orange, New Jersey.

Emergency Schedule on 4th T.C. Line Met With J-K Converter

A sleet storm along the route of the Fourth Transcontinental Line in the latter part of November imposed a severe test on the ability of the Bell System to restore service. In the area most affected, Amarillo, Texas, to Tucumcari, New Mexico, a distance of about 110 miles, the great damage to the open-wire lines made it desirable to route all facilities through new cables which had just been completed between these points. This was accomplished by converting all type-J and type-C carrier systems to a type-K basis at the two ends of the cable. Four systems of each type were involved in addition to two others of each type which had originally been scheduled for this treatment. This marked the first commercial application of the new J-K converter which was recently standardized for this usage. By drawing on all available sources of materials and by thorough coordination of all the agencies involved it was possible for the installation and plant to restore service within the three weeks' time available before the holiday peak.

A. T. & T. National Advertising Program

During 1941, the American Telephone and Telegraph Company will make use of a wide variety of magazines. The program is divided into five series, as follows:

Informative—to remind the public of the inherent values and low cost of telephone service and the character of the organization which renders this service.

Long Lines—to promote the advantages of fast, convenient, inexpensive inter-city communication.

Telephone Convenience—to emphasize the desirability of advance planning for the provision of adequate telephone equipment and service in new and remodeled residences.

Classified Telephone Directory—to promote the use of the Classified as a buying guide; in advertising and business publications, to emphasize the sales and merchandising possibilities of Trade Mark Service.

College—designed to keep the future leaders of business and industry informed of the services, methods and progress of the Bell System and to promote the use of out-of-town service by the college group.

The Telephone Business

The American Telephone and Telegraph Company and its principal operating subsidiaries comprising the Bell System—the largest single communications system in the world—had a marked overall increase in business in 1940. Substantial increases in the number of persons employed and in the outlay for plant construction throughout the system were noted in the year.

For the year as a whole, the operating

William Carroll
of the Plant Department completed forty years of service in the Bell System on the eleventh of December

companies in the Bell System had an aggregate net gain of approximately 949,900 telephones in service. This compared with an increase of 775,000 in 1939 and is the largest annual net gain on record. The largest previous gain was 876,000 in 1937.

Bell System telephones in operation at the end of 1940 amounted to 17,483,800, a new record. Toll business increased, the number of completed toll calls in the year reached approximately 900,000,000 and exceeded the comparable 1939 figure by about 7½ per cent. The daily average of all completed telephone calls, both toll and local, over Bell System lines in 1940 was estimated by A. T. & T. officials at 78,700,000 a day, or nearly 5,000,000 more than the daily average in 1939.

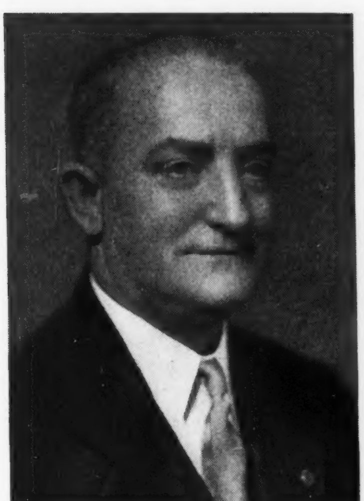
Gross construction expenditures amounted to approximately $380,000,000, the largest plant expansion budget since 1931. This compared with $313,000,000 in 1939 and $296,000,000 in 1938. For 1941, it is estimated that with the added impetus of the national defense program, the Bell System will spend about $450,000,000 gross for additional construction of plant and facilities.

Taxes on the system in 1940 ran almost $30,000,000 higher than in the previous year. Comparative figures on taxes for the last three years are $147,000,000 in 1938; $159,000,000 in 1939, and, according to current estimates, about $188,000,000 in 1940.

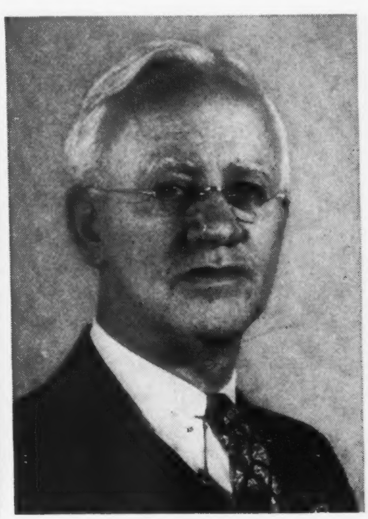
Employees in the entire system, including the Western Electric Company and Bell Telephone Laboratories, numbered about 320,000 at the end of 1940, compared with a total of 297,000 at the end of 1939.

News Notes

Members of the Laboratories who have been granted leaves of absence to enter military service are E. L. Chinnock, U. S. Naval Training Station, Norfolk; W. R. Lyon, Office of Chief of Air Corps, Wash-



J. J. Lohrey
of the Plant Department completed forty years of service in the Bell System on the second of January



W. M. Stuart, Jr.
of the Switching Development Department completed thirty-five years of service in the Bell System on January 19

F. S. Malm
of the Chemical Laboratories completed thirty-five years of service in the Bell System on January 22

R. P. Ashbaugh
of the Outside Plant Development Department completed thirty years of service in the Bell System on January 3

A. D. Hargan
of the Transmission Apparatus Development Department completed thirty-five years of service on January 3

O. D. M. Guthe
of the Patent Department completed thirty-five years of service in the Bell System on the thirtieth of January

ington; F. A. Minks, 101st Signal Battalion, Camp Shelby, Mississippi; A. M. Elliott, 244th Coast Artillery, Virginia Beach, Virginia; Ernest Graunas, Fort Monmouth, New Jersey; Clarence Unnewehr, U. S. S. *Dubuque*, Navy Yard, Boston; K. L. Warthman, Ordnance Reserve Corps; and E. G. Graf, R. C. Nance, T. A. Pariseau and S. C. Tallman, 102nd Cavalry, Fort Jackson, Columbia, South Carolina. Leaves of absence for civilian duty in the Navy Department at Washington have been granted to W. B. Ellwood, J. F. Keithley and A. E. Leitert, Bureau of Ordnance, and J. W. Smith, Radio Section, Bureau of Ships.

Charles G. DuBois, formerly a director of Bell Telephone Laboratories, died on December 30. Mr. DuBois entered the Bell System in 1891 and was president of the Western Electric Company from 1919 until he retired in 1926.

J. A. Becker has been appointed an associate editor of *The Review of Scientific Instruments* to have charge of a program in which the *Review* will carry a series of invited review articles by specialists in their fields on the instruments that are available and their uses in the various branches of physics and the allied sciences. Beginning with the January issue of the *Review* there will be three other features: sections devoted to *New Instruments*, *New Materials* and *Physics* with an associate editor in charge of each. A. R. Olpin, formerly with the Laboratories and now Research Director of The Ohio State University Research Foundation, will be in charge of the *New Materials* section. Until last November, when G. P. Harnwell was appointed editor, Dr. Becker had been acting editor. He has contributed much in carrying on the work of this magazine following Dr. Richtmyer's death and in establishing new policies which are now being carried out.

The engineer shown in the photograph on page 169 is D. E. Bilton.

L. H. Germer spoke on *Electron Diffraction in Metals* before the Brothers College Science Club of Drew University, Madison, New Jersey.

F. S. Goucher, assisted by J. R. Haynes, gave his lecture-demonstration, *The Microphone and Research*, before the Mansfield (Ohio) section of the A.I.E.E. on January 7 and before the Cincinnati section on January 9.

Meetings of the American Physical Society, held in Philadelphia from December 26 to 28, were attended by Harvey Fletcher, A. J. Ahearn, W. H. Brattain, J. A. Becker, K. K. Darrow, L. H.

Germer, A. D. Hagstrum, W. P. Mason, G. L. Pearson and J. N. Shive.

At the Hawthorne plant of the Western Electric Company, R. M. Burns, H. E. Haring and K. G. Compton discussed metal finishes and related developments; D. R. Brobst, wire-development problems; P. Neill, design of switchboard plugs; A. C. Keller and F. H. Hibbard, the manufacture of the new relay-size cam selector; C. C. Barber, flexible brushes for the panel system; and B. M. Bouman, a new design of operator's chair employing plastics instead of wood in the seat and back.

R. M. Foster, on January 13, spoke on the subject *Mathematical Problems in Electrical Network Theory* before the mathematics seminar of Queens College, Flushing, New York.

At a meeting of the Radio Colloquium held at the Holmdel radio laboratory on January 3, G. W. Gilman spoke on the subject *Frequency Modulation, Its History and Applications.*

W. P. Mason spoke before the Boston section of the I.R.E. on December 20. His subject was *New Quartz Crystal Cuts and Their Applications in Oscillators and Filters.*

J. A. Becker attended the semi-annual meeting of the Catholic Round Table of Science, held at Georgian Court College, Lakewood, New Jersey. This group is primarily made up of science professors of colleges in the New York metropolitan area and their formal discussions are usually on some phase of the relationship between science, philosophy and religion.

During the months of December and January the following members of the Laboratories completed twenty years of service in the Bell System:

Apparatus Development Department

W. A. Evans — J. H. Gray — R. J. Kent

Research

C. F. P. Rose

Systems Development

C. L. DuBois

Patent Department

C. F. Campagna — Miss Marion F. Kane

General Accounting Department

A. J. Daly

Commercial Relations Department

P. C. Ryder

General Service

Miss Aileen M. Campbell

Plant Department

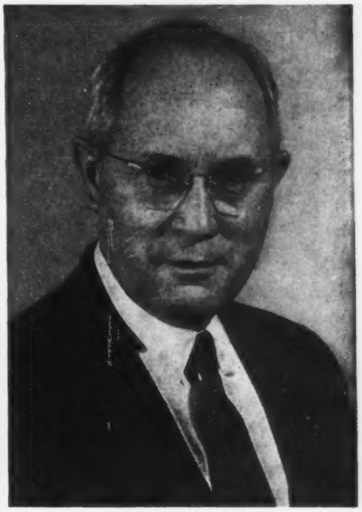
W. C. Somers

R. L. Slobod visited central offices of The Bell Telephone Company of Pennsylvania to make a survey of panel bank contact performance.

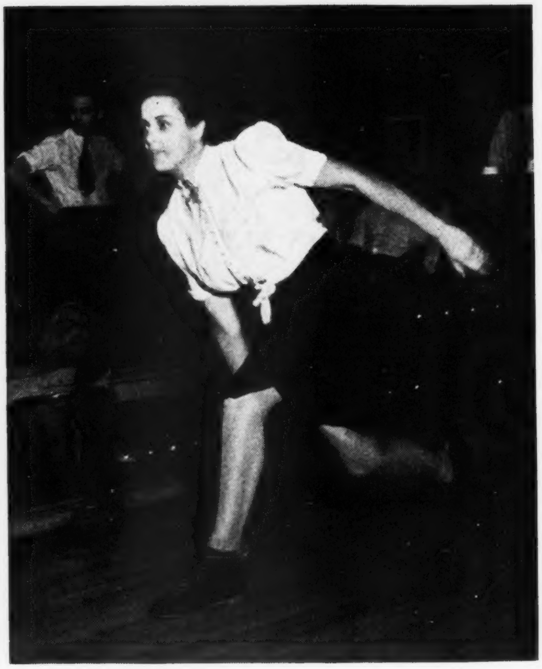
On December 13 C. S. Fuller and C. J. Frosch visited the Extruded Plastics Corporation at Norwalk, Connecticut, where

C. J. Glinane
of the Plant Department completed thirty years of service in the Bell System on the twenty-first of December

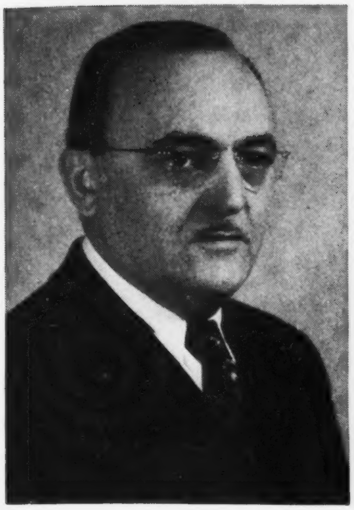
W. A. Bollinger
of the Equipment Development Department completed thirty years of service in the Bell System on December 1



R. L. Young
of the Equipment Development Department completed thirty years of service in the Bell System on January 24



The Women's Bowling League of the Bell Laboratories Club consists of fifty bowlers, thirty of whom are on the six regular teams and ten on the two X-league teams with the balance acting as substitutes. So far this year Helen Whidden has a high score of 223 and Dorothy Johnston, 211. Helen Rottstock has high average of 148 and Priscilla Meeker, 145. The photograph at the top shows, left to right, Helen McArthur, Ann Fleckenstein, Muriel Miller, Jeanette McManus and Mildred Emmons. Below at the left is Helen Rottstock and at the right, Dorothy Johnston



J. J. Catogge
of the Transmission Development Department completed thirty years of service in the Bell System on January 13

W. B. Mosher
of the Transmission Development Department completed twenty-five years of Bell System service on January 3

P. L. Wright
of the Switching Development Department completed thirty years of service in the Bell System on December 12

they witnessed the extrusion of various types of plastics.

Mr. Fuller and W. O. Baker attended meetings, held at Columbia University on December 30 and 31, of the Division of Physical and Inorganic Chemistry of the American Chemical Society.

During the fourth quarter of 1940, the following members of the Laboratories have been enrolled as members of the Telephone Pioneers of America:

G. W. Ames	J. M. J. Harriot
G. B. Baker	P. A. Jeanne
W. H. Berthold	G. R. Martin
W. T. Breckenridge	D. R. McCormack
E. D. Butz	Miss L. M. McMahon
R. A. Chegwidden	G. T. Morris
W. Connick	E. B. Payne
J. H. Cozzens	J. M. Peabody
Miss Statira Crawford	R. P. L. Piltan
Miss Helen Cruger	D. A. Quarles
S. T. Curran	G. A. Roberts
W. L. Daly	A. D. Soper
W. L. Dawson	C. R. Taft
H. A. Flammer	G. M. Thurston
J. J. Gilbert	Dr. J. S. Waterman
C. H. G. Gray	R. R. Williams
E. Hansen	T. J. Young

W. A. MacNair, R. H. Lindsay and J. F. Morrison attended an informal engineering conference held in Washington, D. C., under the auspices of the Federal Communications Commission to give an opportunity to radio manufacturers and others concerned to discuss the establishment of a schedule of standard output power ratings for frequency-modulated broadcast transmitters and to comment on the current performance standards in the light of field experience accumulated since these standards were published by the Commission. Mr. Morrison was made a member of a committee formed during the conference to study antenna and radio frequency transmission line characteristics in the frequency-modulation broadcast service.

K. D. Swartzel spoke on the *Physical Basis of Tone Color* before the Music Teachers' National Association at Cleveland on December 31.

H. W. Hermance visited central offices in Philadelphia and Washington to survey atmospheric conditions affecting contact performance.

A. E. Ruehle visited the duPont plant in Wilmington, Johns Hopkins University in Baltimore and the Bureau of Standards and Smithsonian Institution to discuss infra-red spectroscopy problems.

T. C. Fry attended the meetings of the American Mathematical Society at Baton Rouge, Louisiana.

Harvey Fletcher, J. F. Morrison and Homer Dudley will participate in the Fourth Annual Broadcast Engineering Conference sponsored by the Department of Electrical Engineering of Ohio State University with the coöperation of the National Association of Broadcasters. The conference will be held at the University in Columbus, Ohio, from February 10 to 21. Dr. Fletcher will discuss *Hearing, the Determining Factor for High Fidelity;* Mr. Morrison will speak on *FM Broadcast Transmitter Circuit Design;* and Mr. Dudley, assisted by C. W. Vadersen, will give a lecture-demonstration on *The Vocoder or Remaking Speech Electrically.*

C. A. Webber and W. V. Thompson visited Point Breeze at various times during December to discuss the design of vacuum-tube audiphone cords. R. T. Staples also visited Point Breeze on matters connected with cord development problems.

In the fifth annual photographic exhibition of the American Society of Mechanical Engineers, held in New York City during the recent annual meeting of the Society, several members of the Laboratories had prints hung and E. Alenius, W. L. Betts, C. T. Boyles and N. C. Norman were awarded medals.

During the month of December patents were issued to the following members of the Laboratories:

H. S. Black	G. A. Locke
A. J. Busch	W. P. Mason (2)
G. C. Cummings	P. Mertz
J. W. Dehn	N. Monk
A. C. Dickieson	H. A. Reise
S. Doba, Jr.	H. T. Reeve
J. M. Duguid	J. B. Retallack
J. O. Edson	D. H. Ring
E. L. Erwin	L. C. Roberts (2)
C. D. Hanscom	W. S. Ross
H. Hovland	A. A. Skene
L. W. Hussey	J. O. Smethurst
W. F. Kannenberg	R. R. Stevens
G. V. King	P. W. Swenson
W. E. Kirkpatrick	R. A. Sykes
F. A. Kuntz	C. W. VanDuyne
J. P. Laico	J. M. West
B. F. Lewis	R. O. Wise

Central-office wiring problems were discussed at Kearny by W. L. Casper, E. B. Wheeler, H. H. Glenn and D. R. Brobst and resistance and condenser problems by F. J. Given and P. S. Darnell.

J. R. Townsend attended the annual meeting of the A.S.M.E. in New York City and presided at the session of the Special Research Committee on Mechanical Springs. W. W. Werring attended the meeting of the Committee on Screw Threads and Screw Thread Gaging.

Mr. Townsend delivered an illustrated talk entitled *High-Speed Motion Pictures Aid Design* before the Alumni Association of the Columbia Engineering Schools and addressed the Springfield, Massachusetts, Chapter of the American Society for Metals on *Tools for Testing.*

C. H. Greenall and G. M. Bouton visited Point Breeze in connection with cable sheath problems.

C. H. Wheeler investigated line relays in the Oakland, Lafayette and South Chicago central offices of the Illinois Bell Telephone Company.

* * * * *

On the twentieth of December M. A. Weaver completed a quarter century of service with the American Telephone and Telegraph Company and the Laboratories. After receiving the E.E. degree from Lehigh University in 1915, Mr. Weaver spent several months with the Bethlehem Steel Company. He then joined the Long Lines Department of the American Telephone and Telegraph Company where he was successively engaged in equipment maintenance in Philadelphia, in toll cable installation testing in the New York division, and in toll cable engineering in the Engineering Department.

In 1923 Mr. Weaver was transferred to the transmission development division of the Department of Development and Research to supervise work concerned with crosstalk problems on all types of cable circuits, particularly design features, methods of installation, balancing and testing. When the D and R consolidated with the Laboratories in 1934 he became a member of the Noise Prevention Department and more recently of the Transmission Engineering Department, where he is in charge of one of the groups responsible for handling problems of interference that occur in cables at voice and carrier frequencies.

His work has contributed importantly to the problem of meeting satisfactory cross-

M. A. Weaver

H. A. Richardson

J. M. Maxey

talk objectives in toll cable circuits, beginning with the installation of the second New York-Philadelphia cable in 1916 and the thousands of miles of cable installed since then. Recently, the work of his group on crosstalk and noise has contributed to the success of the type-K cable-carrier system. This included formulation of methods for crosstalk reduction and noise prevention, studies of cable designs, and associated field and laboratory testing.

* * * * *

On January 10, H. A. Richardson received a five-star emblem, symbolizing his completion of twenty-five years of service in the Bell System. Mr. Richardson joined the Engineering Department of the Western Electric Company as a messenger in 1916. A little over a year later he transferred to the circuit design drafting group of the Systems Development Department. During 1918 he left to join the 30th Service Company of the U. S. Signal Corps with which he served ten months, being stationed in New York City.

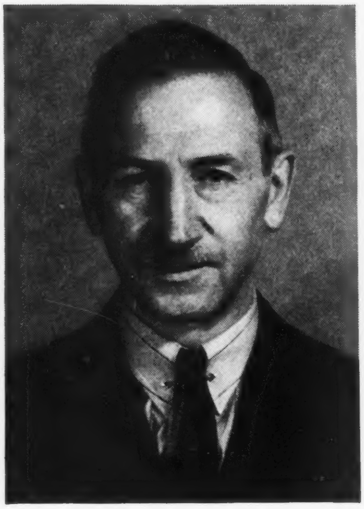
When Mr. Richardson returned to West Street following the war he entered the circuit laboratory where he was concerned with the wiring and testing of local and telegraph circuits, particularly those associated with manual systems. Two years later he went to the step-by-step laboratory as a tester and later to the current-drain analysis group. From 1920 to 1926 he studied electrical engineering at the Polytechnic Institute of Brooklyn. Since 1927 Mr. Richardson has been in the apparatus requirement group of what is now the Switching Development Department where he has been associated with the preparation of Bell System Practices. This work involves the preparation of requirements and procedures which are followed by the Installation Department of the Western Electric Company and the maintenance forces of the Operating Companies in maintaining the apparatus in satisfactory conditions for service to the telephone subscriber. They cover all central-office, outside plant and subscriber equipment and apparatus. Mr. Richardson is associated particularly with panel-office phases of this work.

* * * * *

J. M. Maxey of the Apparatus Development Department completed twenty-five years of service in the Western Electric Company and the Laboratories on the tenth of January. Mr. Maxey joined the apparatus drafting group of the Western Electric Company in 1916 where he spent two years on the design of telephone dials, then worked on the 10A telegraph printer and finally two years checking drafting work in all types of station apparatus. In 1921 he transferred to the specifications group concerned with general specification work on station and central-office apparatus such as mounting plates, subscriber sets and cords.

Mr. Maxey transferred to the Telephone Apparatus Development Department in 1923 where he was engaged in the design of

F. C. KAHNT



ANTON LODER

J. E. ROGERS

station apparatus, particularly subscriber sets, telephone sets and coin collectors. He continued in this work until the end of 1940 when he joined the Repaired Apparatus Group of the Transmission Apparatus Development Department where his work is on repair and maintenance practices, particularly on station apparatus.

* * * * *

J. E. ROGERS of the Systems Development Department completed twenty-five years of service in the Bell System on the fifteenth of December. He attended the University of Pennsylvania and then, in 1913, joined The Bell Telephone Company of Pennsylvania where he was engaged in apparatus installation, line work and then central-office maintenance in Jenkintown and Norristown. He came to New York to study the call-distribution system and then went to Wilmington to make pre-cutover and acceptance tests on this equipment. Mr. Rogers left the Bell System in 1916 and for the next two and a half years was in the electrical contracting business.

Mr. Rogers joined the Engineering Department of the Western Electric Company late in 1918 and until 1923 was concerned with laboratory testing of semi-mechanical and call-distributing systems, step-by-step systems, and interconnecting circuits for manual, panel and toll offices and PBX's. He then transferred to the circuit design group where he was engaged on circuits for private branch exchanges. In 1929 he returned to the laboratory test group where he was concerned with the testing of apparatus and circuits for manual switchboards. Among the more important projects were the No. 3 and No. 4 order-turret circuits; various electric clock mechanisms for use with overtime charging circuits; tests of centralized information and testing circuits; and tests during the development of the 35D test set. Since 1935 Mr. Rogers has been engaged with laboratory equipment for local and toll crossbar systems.

* * * * *

A five-star emblem, signifying the completion of a quarter century of service in the Bell System, was awarded to ANTON LODER on the nineteenth of December. Before joining the Bell System Mr. Loder worked for two years for the Singer Sewing Machine Company at Elizabethport, New Jersey. He first joined the Development Shop of the Western Electric Company in 1914 and worked as an instrument maker on printing telegraph equipment and then on radio apparatus for the Signal Corps. Late in 1917 he left the company and went with the M. I. Instrument Company where he worked on apparatus they were making for the Western Electric Company.

Mr. Loder returned to the Development Shop in 1919 and for the next fourteen years was engaged as an instrument maker with a variety of telephone apparatus, particularly

for transatlantic and ship-to-shore service. In 1933 he transferred to the design and wiring group of the Research Staff Department on special wiring and mechanical work of an experimental nature as required by various members of the Research Department. Since 1938 Mr. Loder has been engaged in the same general type of work for the broad-band cable group of the Transmission Development Department.

* * * * *

F. C. KAHNT completed twenty-five years of service in the Western Electric Company and the Laboratories on the twenty-fourth of December. Previous to joining the Western Electric Company in 1915, Mr. Kahnt had worked as a millwright for fifteen years in other concerns and continued this type of work for the Western Electric. During the World War he was with the 345th Machine Gun Battalion of the 90th Division for fifteen months, one year of this time being spent in France. The last three months of his military service was with the Army of Occupation in Germany.

In 1921 Mr. Kahnt transferred from Building Shops to Building Service where he was a supervisor for a year and a half. For the past seventeen years he has been in the metallurgical laboratory of the Chemical Department in the basement of Section H engaged in the operation and maintenance of tape-rolling and slitting machines and apparatus for grinding fine metal powders. He was instrumental in developing and constructing equipment for tape slitting and trimming and for a furnace that is used for pot annealing.

* * *

E. L. FISHER attended a meeting of the Subcommittee on Electrical Protection of the Association of American Railroads held in New York City on December 6.

The lubrication of step-by-step switches in the Old Greenwich and Bridgeport central offices of The Southern New England Telephone Company was investigated by G. H. DOWNES, G. GARBACZ and F. HARDY. They were accompanied by C. B. CAMPBELL of the A. T. & T.

R. L. JONES has been appointed Bell System representative on the Aviation Radio Committee of the Defense Communications Board.

R. V. TERRY visited the Haydon Manufacturing Company at Forestville, Connecticut, in connection with switchboard position clocks, and the New England Telephone and Telegraph Company, Springfield, in regard to neoprene rolls for the pneumatic ticket distributor system.

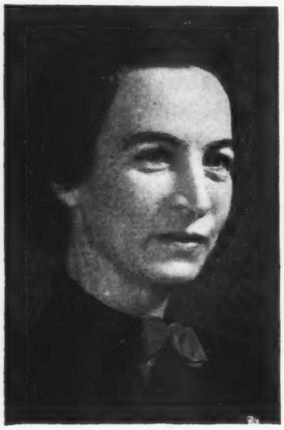
V. F. BOHMAN inspected the trial installation of step-by-step banks at the Fairfield, Connecticut, exchange of The Southern New England Telephone Company.

J. T. KANE of Hawthorne recently visited the Laboratories to discuss step-by-step relay problems.

R. H. COLLEY attended the annual meeting of the American Association for the

G. T. Ford inspects the first installation of the 3-CF toll switchboard, which provides assistance service and toll facilities for dial subscribers at Lock Haven, Pennsylvania. L. W. Gavett, General Traffic Engineer, The Bell Telephone Company of Pennsylvania, Central Area, is on the left

Instructors of Six Out-of-Hour Courses, 1940-1941

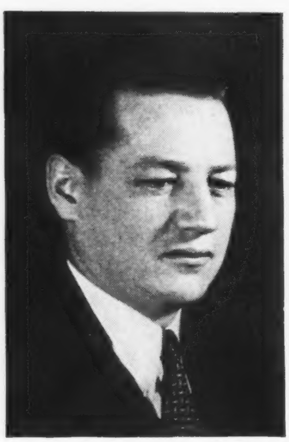


Miss M. C. Brainard
Practice in Shorthand Dictation

R. O. Rippere
Step-by-Step Dial System

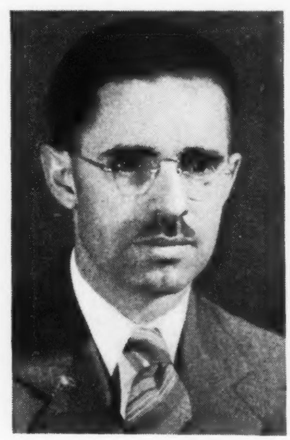
W. D. Goodale, Jr.
Review of Engineering Mathematics

H. N. Wagar
Electromagnets and Telephone Relays



L. T. Anderson

E. J. Donohue
Crossbar Dial System



J. D. Tebo

C. C. Barber
Manufacturing Methods

Advancement of Science held in Philadelphia on December 28.

M. R. Purvis was in Pittsburgh, Columbus and Philadelphia to check the operation and make acceptance tests of intertoll-trunk equipment with automatic signalling. This field trial is a first step in the development of semi-automatic inward and through TWX switching arrangements.

At Cleveland, E. G. Andrews, C. V. Taplin and R. G. Koontz, with Western Electric and A. T. & T. engineers, discussed crossbar addition problems with engineers of The Ohio Bell Telephone Company.

Miss A. M. White of the Equipment Development Department completed twenty-five years of service with the Western Electric Company and the Laboratories on the twenty-fourth of January.

J. G. Ferguson, at Bethlehem, discussed step-by-step central-office equipment.

H. T. Langabeer, at Washington, discussed power equipment for Government private-branch exchanges.

L. J. Purgett was in Hawthorne on general power questions and at some fifteen small central offices in the middle west making current-drain studies.

D. E. Trucksess was in Eau Claire, Wisconsin, in connection with the use of inverted rectifiers in the coaxial cable plants.

F. F. Siebert studied Diesel engine requirements with engineers of The Ohio Bell Telephone Company at Cleveland.

F. T. Forster was in Philadelphia during December discussing battery design with the manufacturer.

J. H. Sole visited Cleveland, Ohio, and Lynn, Massachusetts, for the purpose of discussing generator design questions with the manufacturer of the equipment.

V. T. Callahan discussed engines and gasoline pumps at Pittsburgh, Canton, Minneapolis, Baldwin and Neillsville (Wisconsin), Omaha, and Cedar Falls (Iowa).

J. H. Harding spent the greater part of the four months from August to November in making d-c earth-resistivity measurements in the midwest from Texas north to Wisconsin and also in the territory from Laramie and Cheyenne, Wyoming, to Denver. G. Wascheck aided in some of the testing in the Kansas and Nebraska locations.

C. W. Tucker, Jr., has been elected to Mu Alpha Omicron, the scholastic honor society of the Cooper Union Schools of Engineering.

R. S. Decker, K. G. Compton and H. G. Arlt spent several days at Kearny discussing finish problems.

A. J. Aikens, R. P. Booth, E. D. Guernsey, J. Mallett, and R. S. Tucker took part in tests of the inductive effects of long-wave radio signals on type-C and type-K carrier systems in Virginia and in North and South Carolina.

D. F. Hoth attended the recent meetings of the Acoustical Society in Chicago and presented a paper entitled *Room Noise Spectra at Subscribers' Telephone Locations*.

D. F. Seacord, at Chicago and Cleveland, made measurements of contact noise and vibration in panel offices.

C. H. G. Gray discussed transmission problems with engineers of the Illinois Bell Telephone Company at Chicago. He also attended the recent meetings of the Acoustical Society and of the Sectional Committee on Acoustics of the American Standards Association. Transmission matters were also discussed with engineers of The Ohio Bell Telephone Company at Cleveland.

J. C. Lozier has been in Crisfield, Maryland, in connection with the installation of a radio circuit to Smith and Tangier Islands.

F. E. DeMotte has returned from the Minneapolis-Stevens Point coaxial terminal project on which he has been spending considerable time, and R. E. Crane and G. H. Huber visited the coaxial installation at Minneapolis and Stevens Point.

In a recent issue of the *Telecommunication Journal of Australia* there appeared an article on the *Sydney-Melbourne Type-J Carrier Telephone System* by J. T. O'Leary of the Laboratories and J. B. Scott and A. M. Thornton of Standard Telephones and Cables. Mr. O'Leary spent some time in Australia assisting in the installation of this carrier system.

The laboratory of the Hazeltine Service Corporation at Little Neck, Long Island, was inspected by H. W. Evans, H. J. Fisher, E. I. Green and P. Mertz.

B. Dysart, B. A. Fairweather, and V. M. Meserve were in attendance during the holiday period at Stevens Point and Minneapolis while the Long Lines Department was operating the coaxial system between these two points for commercial traffic. On Christmas and New Year's days 39 commercial circuits were in use over this cable. During the entire period the system operated without any service interruptions.

D. S. Barlow and R. S. Hawkins set up a video television circuit for the Philco Radio Corporation in Philadelphia from the Arena to Convention Hall for use in their broadcasting of television pictures.

R. J. Shank visited the Radio Corporation of America in Camden to get detailed instructions in the operation of a new television camera which is being built for the Laboratories.

During the month of December, K. C. Black and H. H. Benning were in Eau Claire to make development studies of the coaxial cable between Stevens Point and Minneapolis.

The carrier telephone development program for 1941 was discussed by H. A. Affel, K. C. Black, H. S. Black, D. C. Meyer, D. A. Quarles and J. F. Wentz with engineers of the Western Electric Company at Kearny.

J. W. Schmied and H. O. Wright were at the Patent Office in Washington during December relative to routine patent matters.

The Fall Meeting of the Middle Atlantic Section of The Society for the Promotion of Engineering Education, held at the University of Pennsylvania on December 14, was attended by G. B. Thomas, R. A. Deller, M. S. Mason and E. W. Waters.

I. MacDonald and R. J. Guenther appeared before the Board of Appeals at the Patent Office in Washington relative to applications for patent.

The Laboratories were represented in interference proceedings at the Patent Office by H. S. Wertz.

W. H. Harrison, Director of the Laboratories, Receives New Defense Post

W. H. Harrison, Vice President of the American Telephone and Telegraph Company and a director of the Laboratories, has been given an important new assignment in National Defense. As reported by Roland C. Davies, Editor of *Telecommunications Reports* in the issue of January 22, "Mr. Harrison, who has been on leave for the past seven months in charge of construction for Mr. Knudsen's Production Division of the old National Defense Advisory Commission, was assigned January 18 to a highly important key post in the newly organized Office of Production Management. He will be the Chief Executive in charge of Production of Shipbuilding (both naval and commercial), Construction (Army cantonments and airfields, Navy bases and air stations, munitions factories and expansion of existing plants) and Supplies (which will embrace all supplies sought by the Army Quartermaster Corps, Chemical Warfare Service, Medical Service and Signal Corps and by comparable branches of the Navy).

"Broadly speaking, Mr. Harrison's work will be executive and administrative to accelerate and coördinate the production of the needed supplies, the construction work and shipbuilding after the Army and Navy have determined what they require. His department will expedite through continuous coördination activities and servicing of production and construction between the placing of the orders by the Army and Navy and the final inspection and acceptance by the armed services. In connection with the production of Signal Corps apparatus as well as in other fields of supplies, the major servicing part of Mr. Harrison's new department is to keep an even flow of component products and parts that go into munitions, aircraft and Army and Navy supply needs. For example, the radio apparatus for airplanes must be ready at the exact time when they are to be installed in the airplane.

"During his administration of the construction activities for NDAC, Mr. Harrison achieved remarkable accomplishments —the attacks and criticisms which have emanated in many newspaper columns and press articles have not been founded on facts that are available in the Army and Navy progress reports. The overall construction program, it may be stated from most authoritative governmental sources, has kept pace and has been reasonably well in line with the induction of the Army's troops and Naval forces into service and has met the production requirements through the building of additional munitions plants as well as in expansion of all types of existing defense material producing factories. Most significant to the telephone industry is the unanimous and prevailing opinion in Army and Navy circles that the construction and installation of telephone facilities in all the new Army and Navy establishments and for the new munitions and industrial plants has practically without exception been ahead—far so in many cases—of the construction work itself. In fact, the telephone service, because of the advance engineering and planning of that industry in meeting national defense demands, has not produced any 'headaches' among the defense authorities, it is learned from many sources."

Earth Resistivity Measurements

By G. WASCHECK
Systems Development

ALTHOUGH the earth is a poor conductor of electricity, its extent is so great that it adds comparatively little resistance to direct-current circuits with earth-return such as telegraph circuits, provided they have good ground connections. In alternating-current circuits which have earth-return, however, the earth's resistivity and the varying magnetic fields which accompany alternating currents change the distribution of the return currents in the earth. This affects the self-impedance of the circuits, and particularly their coupling with neighboring ground-return circuits. Many communication problems are concerned with the currents or voltages in circuits which have the conductors of a metallic communication circuit in parallel on one side and the earth-return on the other. Such circuits are called "longitudinal circuits."*

The resistivity of the earth varies with location from about 1 to over 10,000 meter-ohms,† and hence it must be measured in the immediate region of interest for precise calculations involving this quantity. Values may be determined either by direct or alternating current. With the direct-current method, which is often employed because it is simple, a potential is applied to a pair of ground elec-

*Record, *September*, 1939, *p.* 2.

†The resistivity in meter-ohms is the resistance between opposite faces of a cube one meter on a side.

trodes to form a primary circuit and the potential between two other points is measured for a given current in the primary. Periodically reversing the current reduces polarization at the ground electrodes and stray voltage effects. This measurement is equivalent to determining the mutual resistance between the two circuits. From it and the geometrical arrangement of the electrodes, the value of the earth resistivity, if uniform, may be determined by a simple formula. In using the direct-current method, care must be taken to avoid buried conductors, such as iron pipes and lead cables, since these affect the measurements.

If the earth were homogeneous, one measurement would determine its resistivity for all circuits and at any alternating-current frequency, but the earth structure varies greatly and it is necessary to determine possible variations of resistivity with depth as well as variations at different locations on the surface. To detect variations with depth, successive measurements of mutual resistance are made between electrodes which are moved progressively farther apart in a straight line from a fixed midpoint. The outer two electrodes are usually taken as the current or primary electrodes and the inner ones as po-

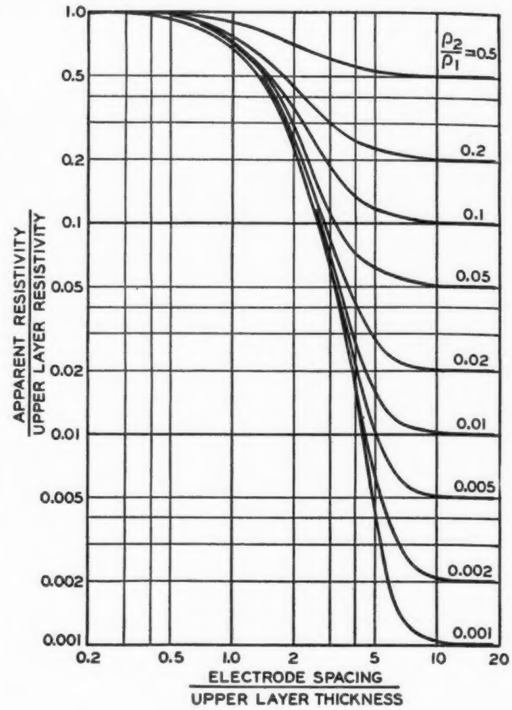


Fig. 2—The thickness of the earth layer at the surface is computed by comparing a curve of the measured resistivity for different spacings with a family of theoretical curves, for different resistivity ratios of the upper and lower layer, plotted against the ratio of the spacing to the thickness of the upper layer. The upper-layer resistivity equals the apparent resistivity for close electrode spacings. The curves are for values of the ratio, ρ_2/ρ_1, of the lower layer to the upper layer resistivity which are less than unity

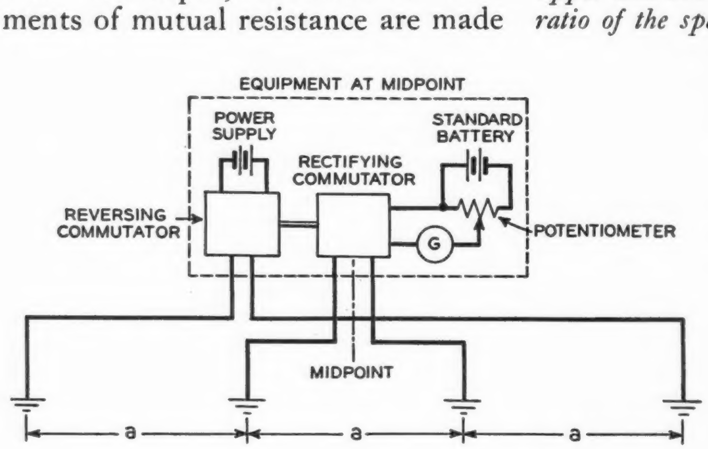


Fig. 1—Earth resistivity measurements are made by determining the drop of potential between two grounded electrodes in the path of earth currents established between two other grounded electrodes which are from a few feet to half a mile or more apart. The apparatus for making these measurements is placed at the mid-point of the circuit

tential or secondary probes, although the reverse order would give the same results. The generating and measuring apparatus is placed at the midpoint with wires extending to the separate electrodes in a symmetrical manner, as shown in Figure 1. The spacing between ground electrodes is progressively increased, at a geometric rate, from a few feet to half a mile or more depending on the resistivity trend. The depth to which information regarding earth structure and resistivity is obtained for given spacings varies with the absolute values of the different resistivities and the order in which they are encountered.

The measurements may be made with sensitive direct-current meters on which direct and reversed readings are taken to eliminate effects from stray direct current and galvanic potentials. To produce frequent and automatic reversals of current, a test set, shown on page 185, was designed. It includes a primary source of power, a reversing commutator for the primary circuit, a similar rectifying commutator, which rotates on the same shaft, for the secondary circuit, and a potentiometer with standard battery and galvanometer to detect null balances. Direct current from several heavy-duty batteries or a gas engine-driven generator is used. The rectifying commutator is usually set so that the potential contacts are closed after the current contacts to avoid transient effects. A double-pole, double-throw switch permits measurement of either the potential drop across a shunt in series with the primary circuit or the voltage in the secondary circuit. The rectifying commutator delivers a unidirectional pulsating voltage to the galvanometer circuit. This voltage is opposed by the potential from the standard battery across a voltage divider with a calibrated dial. A sensitive galvanometer, which is connected in the circuit synchronously with the pulsating voltage, detects balance when no current appears in this circuit. Both the shunt drop and the secondary voltage are determined by a potentiometric null balance and since the two are balanced against the same standard battery, the mutual resistance is equal to the ratio of the two dial readings multiplied by the shunt resistance, which is made equal to unity for convenience. When excessive stray direct voltages are encountered they may be blocked out by a condenser placed in series with the secondary circuit. This does not

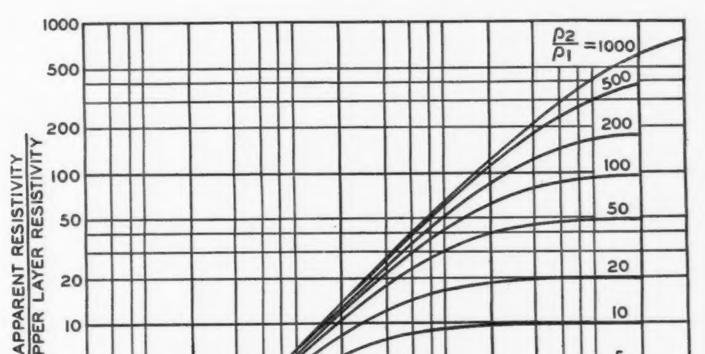


Fig. 3—A family of curves similar to those of Figure 2 but for values of the ratio, ρ_2/ρ_1, of the lower layer to the upper layer resistivity which are greater than unity

interfere with measurement of the desired voltage since the latter is periodically reversed, thus causing a transient charging current to flow at each reversal. A uni-directional current comes from the rectifying commutator until balance is secured.

The resistivities calculated from experimental data often show a transition from one value to another as the spacing between current and potential electrodes is increased from initially small values. This characteristic, especially when duplicated at neighboring locations, usually indicates a stratified earth. With close spacing of electrodes the current is necessarily concentrated near the surface and yields surface voltages dependent only on the near-surface characteristics, whereas with larger spacings the current penetrates to lower depths and surface measurements will reflect the characteristics of the underlying medium. The hypothesis of a stratified structure is corroborated by geological studies which show that a large portion of the earth's surface has been formed by layer deposits.

The simplest type of stratified earth would be two horizontal layers with the lower one infinite in depth. The experimental resistivities would then approach the resistivity of the upper layer at the small spacings and that of the lower at the larger spacings. The transition depends on the thickness of the upper layer and the resistivity ratio of the two layers. These quantitites are determined from a set of field measurements by reference to families of theoretical curves, each for a different ratio of lower layer to upper layer resistivity. The curves are plotted on log paper, with the ratio of apparent resistivity to upper-layer resistivity as ordinates, and the ratio of electrode spacing to upper-layer thickness as abscissae. Curves of this kind are shown in Figure 2 and Figure 3 for ratios of apparent to upper layer earth resistivity less than

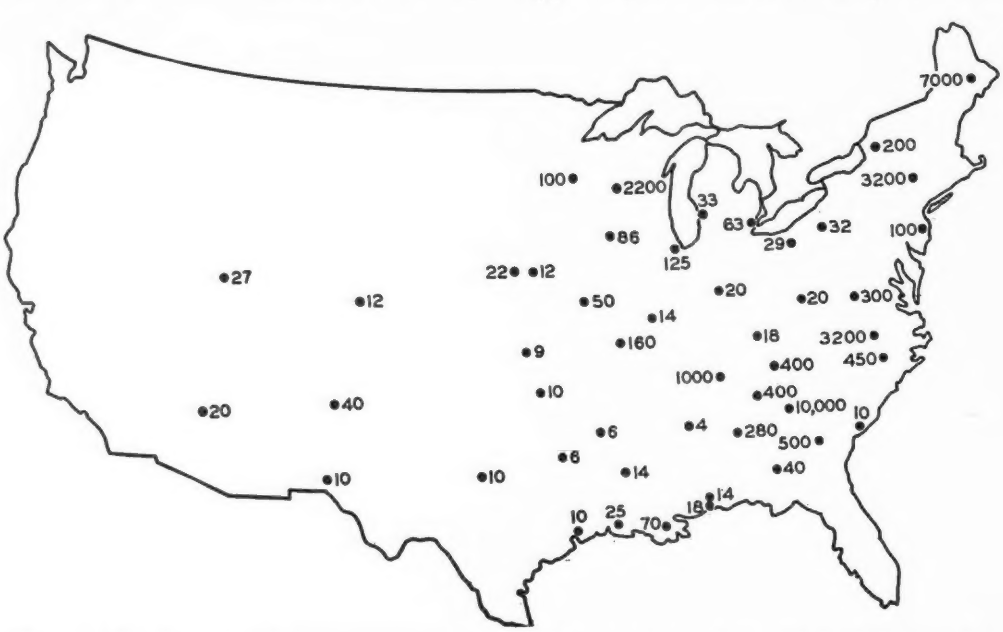


Fig. 4—Earth resistivity measurements in different parts of the United States show that the resistivities are usually lower in regions of recent geological origin. The values are expressed in ohms for a meter cube

or greater than one, respectively. The experimental results are plotted to the same scale as the theoretical curves by using as ordinates the ratio of apparent to upper layer resistivity —the latter is taken as equal to the apparent resistivity at the closer electrode spacings. As abscissae the electrode spacings are used and they are interpreted as the ratio of electrode spacing to an upper layer depth of unity. The experimental curve is superposed on the family of theoretical curves which it most nearly resembles in shape, and is slid along laterally until a fit is obtained. The ratio of lower to upper layer resistivity is found and the depth of the upper layer is determined by comparing corresponding points on the axes of abscissae.

Since the earth may be approximated by a horizontally stratified two-layer structure in a majority of locations, the coupling between two ground-return circuits may be determined by reference to coupling curves plotted for this condition. When the region portrays more complicated variations with spacing, the nearest two-layer equivalent structure or an average uniform resistivity is estimated. Usually an involved variation of resistivity with depth is also accompanied by variations from one location to the next so that a greatly detailed investigation of variations of resistivity is not warranted. The best overall resistivity must still be an average of those indicated at the locations explored.

By comparing the results of measurements at over one hundred locations throughout the United States, an attempt has been made to correlate the resistivities with the geological structure of the earth in the same region. The experimental sites have been spotted on maps which cover a major portion of the United States and labeled with the average resistivities determined from the tests as illustrated in Figure 4. These data, correlated by R. H. Card, show that the resistivity is usually lower and the structure more regular in regions of recent geological origin than in those identified with the older pre-Cambrian rock, although alluvial deposits and glacial drifts influence a local resistivity. With the maps and a knowledge of the geological details it is now possible to make an approximate estimate of the magnitude of the resistivity and the possible heterogeneity of the sub-surface structure for most areas. This is often sufficient for preliminary estimates, though measurements are necessary for more precise figures.

Earth resistivity measurements are not only useful in studies of inductive effects in telephone lines from existing exposures to power circuits, but also to determine the expected induction in locations where the construction of new lines is contemplated. In electrolysis and lightning studies a knowledge of the resistivity near the surface of the earth is often quite important.

Power-Factor Correction Equipment for Central Offices

By L. J. PURGETT
Power Plant Development

TELEPHONE power plants employ motor-generator sets to supply 24-volt and 48-volt direct current for the main office supply, and a number of smaller sets to supply ringing, signalling, and tones. In a panel office there will also be a number of small motors to operate the elevators on the panel frames. These motors all operate at a lagging power factor, which varies in value with the percentage of full load

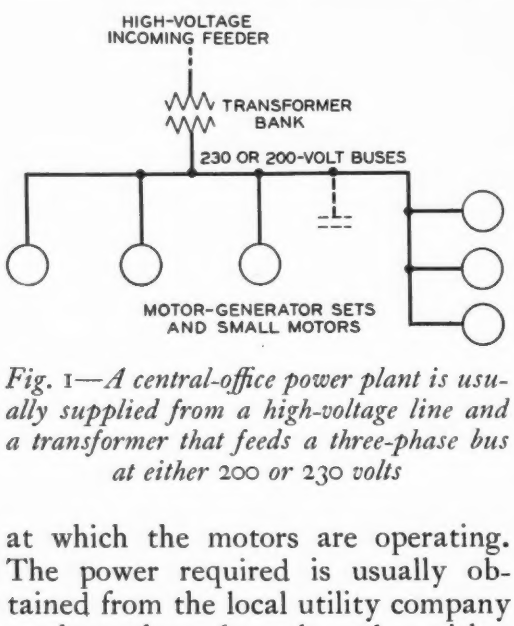


Fig. 1—*A central-office power plant is usually supplied from a high-voltage line and a transformer that feeds a three-phase bus at either* 200 *or* 230 *volts*

at which the motors are operating. The power required is usually obtained from the local utility company at three-phase 60-cycle and at either 200 or 230 volts nominal circuit potential. The rate paid not infrequently depends in one way or another on the power factor, and the telephone companies have generally attempted to maintain a high power factor by the use of synchronous motors. Such motors are more expensive than induction motors, however, and are much more expensive to maintain, and so their use is not always justified. It has been found difficult, moreover, to obtain synchronous motors that do not generate harmonic potentials that may cause noise in telephone circuits. This difficulty, together with the recent availability of an inexpensive condenser suitable for power-factor correction, led to a survey of the entire situation and the provision of a line of capacitor-reactor units that would give economical and satisfactory correction for telephone power plants, particularly those of the larger 301C type.*

A generalized central-office power supply system is indicated in Figure 1, where for the sake of simplicity a single line is used to represent a three-phase circuit. The load current is at 60 cycles, but on the incoming feeder there also may be voltages of any or all of the odd harmonics of 60 cycles. These usually are relatively small in value, and because of the high impedance of the power plant equipment to these higher frequencies, the high-frequency currents are usually too small to induce objectionable noise in nearby telephone circuits. If a condenser is connected to the

*RECORD, *Oct.*, 1937, *p.* 43.

bus to improve the power factor, as indicated by the dotted lines, the situation is changed, however. The feeder, including the transformer, has inductive reactance and thus at some frequency would form a resonant circuit with the condenser. Under these conditions the impedance to the resonant frequency is only the resistance of the circuit, which is very small. As a result a relatively large value of the harmonic current may flow and cause disturbances in telephone circuits paralleling the power supply feeder. Before recommending such a condenser installation, therefore, all likely conditions must be determined, and precautions taken to avoid objectionable disturbances.

This is not the only thing that must be considered, however. The load of the plant, flowing through the impedance of the feeder and transformer, results in a drop in voltage when the power factor is lagging. From no load to full load this drop is of the order of 5 per cent, but it depends on power factor, and at leading power factors it results in an increase instead of a decrease in voltage, which may become great enough to be objectionable. If a separate condenser were used for each motor, there would not be much likelihood of high voltage because each condenser is proportional to the size of the motor, and when the motor is disconnected, the condenser also is disconnected. With a single group of condensers connected to the bus at all times, however, this is not true. The condenser must of necessity be large enough to give the required correction at full load, and at light load, as a result, its large leading current may result in a low leading power factor, and the voltage at the bus will necessarily rise. The use of separate condensers on each motor feeder is more expensive than using a single large condenser, and thus was not felt advisable, but as a result it became necessary to consider the possibility of high voltage in designing the corrective equipment. It was also necessary to make sure that under no condition would the voltage across the condensers themselves become higher than the limits recommended by the manufacturers.

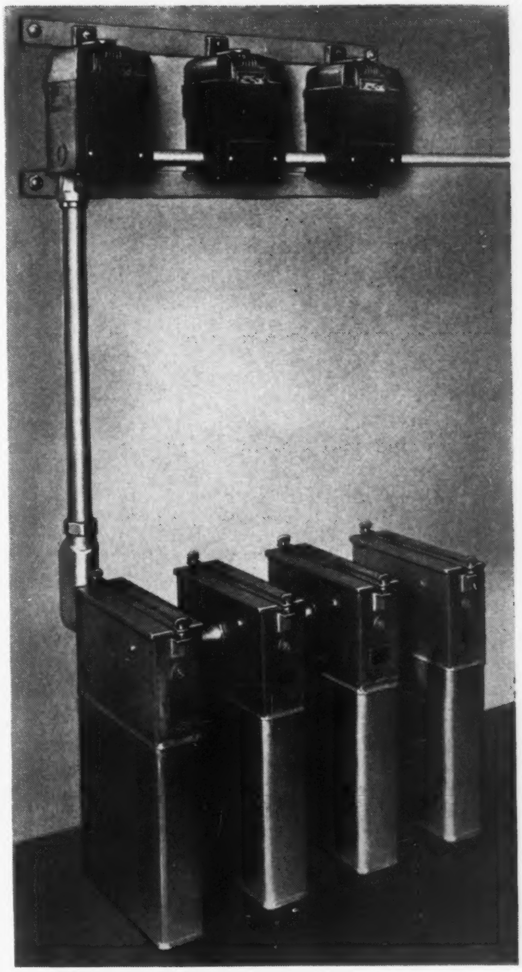


Fig. 2—Each installation consists of one or more condenser units and three reactors

In undertaking the development it was necessary first to determine the range of load of the various possible power plants and also the variations in load at different times of day. Once

this is determined, it is possible to correlate the standard sizes of capacitors available so as to make proper recommendations for the various sizes and types of offices. It was necessary, in addition, to design the equipment so that the higher harmonics would not cause interference with exposed telephone circuits and so that excessive voltages would not appear.

To reduce the effect of the condenser on the harmonic currents, it was decided to install a reactor in series with it. With a condenser and reactor in series, the combination is resonant at some one frequency, and at this frequency its reactance is zero. Below this frequency the reactance is capacitive and above it, it is inductive—rising rapidly with frequency at both sides of the resonance point. By selecting a reactor that would bring the resonance frequency above 60 cycles but below the frequency of the lowest important harmonic, therefore, leading current would be obtained at 60 cycles for power-factor correction, and a high-inductive reactance would be presented to the harmonic frequencies.

The lowest odd harmonic is 180 cycles, but on a three-phase supply the 180-cycle voltage between phase wires is small. While it would be undesirable to have resonance come at 180 cycles, there would be no harm in having it fairly near it. The major objective was to bring resonance well below 300 cycles, which is the lowest harmonic potential likely to exist.

The standard capacitors available, which are all three-phase delta-connected units, are as follows:

230 Volts		460 Volts	
KVA	MF	KVA	MF
2.5	125	6	75
5.0	250	10	125
		15	189

When connected in a circuit in series with reactors, the arrangement would be as in the upper sketch of Figure 3. For convenience in calculation, however, the values for an equivalent impedance in a Y-connected group, as shown in the lower sketch of Figure 3, are used. Since the equivalent Y capacitance is three times the Δ capacitance, the values to be used may be taken directly from data given above, where the capacitance listed is the total capacitance of the unit or three times that in one leg of the Δ. From this value of capacitance, the reactance may readily be calculated from the equation $X_C = 10^6/2\pi fC$.

Considering only one phase of the three-phase Y circuit, the circuit is as shown in Figure 4, where V represents the line voltage. The phase to neutral voltage, which is that across the condenser and reactor in series, is $V/\sqrt{3}$. Since the voltages across C and L are in phase opposition, $V/\sqrt{3}$ will be the difference between V_C and V_L rather than their sum. For a 200-volt circuit, $V/\sqrt{3}$ is 115.6 volts, so that the difference between V_C and V_L must be 115.6, and the inductance L of the reactor must be so chosen in relation to the value of C that this difference in voltage will result. This voltage does not determine a single value of inductance, however, because there are an infinite number of pairs of values for V_C and V_L that give the same difference. This difference relationship merely means that V_L is 115.6 volts less than V_C. According to the manufacturer's specifications, however, it is not safe to operate the condenser at a line-line voltage of more than 240 volts, and this fact determines the upper permissible limit for V_L, and thus for the inductance.

Since it is desirable to operate the condenser at its maximum voltage if

possible, so as to utilize its capacity to the greatest extent, the value of inductance chosen is that which will make V_C equal to $240/\sqrt{3} = 138.7$ volts, providing this brings the resonant frequency within the desired range. To meet the requirements of the various sizes of plants, a number of sizes of reactor-capacitor banks will have to be provided. Since only the available sizes of capacitors can be used, however, the value of capacitance will always be some multiple of one of the values given. For the 5.0-kva capacitor units, for example, the equivalent phase-neutral capacitance will be 250*n* microfarads, where *n* is an integer representing the number of capacitor units used. The capacitive reactance X_C is $10^6/2\pi fC$, and thus at 60 cycles will be $10.62/n$ ohms. The maximum permissible voltage of 240 gives $240/\sqrt{3}$ or 138.7 volts for the equivalent phase to neutral, and thus the current through the capacitors will be this voltage divided by the reactance, or 13.05*n* amperes. The voltage across the inductor will be 138.7 minus the line voltage of 115.6, which is the Y equivalent of 200 volts. This gives 23.1 volts across the reactor, and since the current in the reactor is the same as that in the capacitor, the inductive reactance X_L

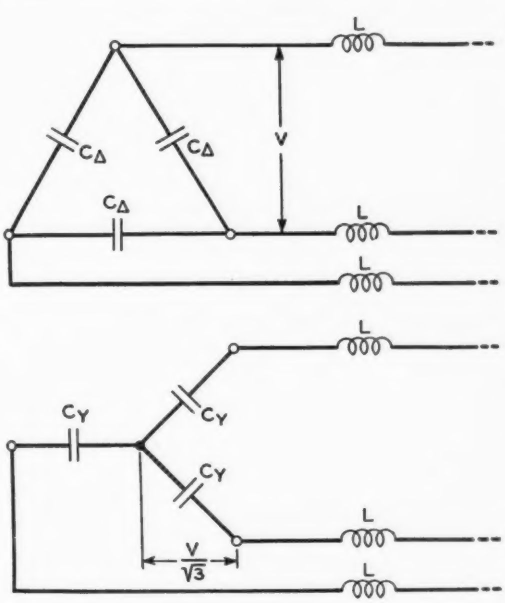


Fig. 3—Three condensers connected in delta, above, will have the same effect as three connected in Y provided the latter have three times the capacitance

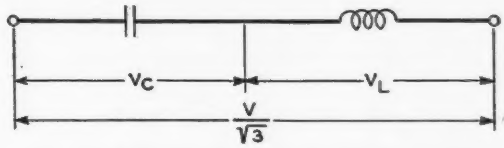


Fig. 4—With a Y-connected capacitor, one of the condensers and the series inductor divide the phase to neutral voltage

will be $23.1/13.05n$, or $1.77/n$ ohms. Since X_L is equal to $2\pi fL \times 10^{-3}$, L is found to be $4.69 \times 10^{-3}/n$ millihenrys.

The resonant frequency is given by the expression $f_r = 1/2\pi\sqrt{LC}$ and by substituting the above values of L (henrys) and C (farads) into this equation, the resonant frequency is found to be 147 cycles regardless of the value of *n*, which cancels out. Since this frequency falls in the permissible range of frequencies, the design can be made on the basis of using the highest permissible voltage across the condensers. Units have been designed using 1, 2, and 4 of the condensers, that is, the *n* in the above expressions is given one of these values for each of three designs. The capacity of these units in reactive kilovolt-amperes will be $3\,I^2\,(X_C - X_L)\,10^{-3}$ and by substituting the above values into this expression, the capacity is found to be 4.55 *n* reactive kilovolt-amperes. For the three values of *n*, this gives the five capacities 4.55, 9.10 and 18.2. For larger capacities, two or more of the 18.2-kva units are installed to give required capacities. By using a

single one of the smaller, or 2.5-kva condensers, a capacity of 2.77 reactive kva is also secured.

Similar calculations are carried out for 230-volt circuits, but here, because of the higher voltage, it was necessary to use the 460-volt capacitors.

In installing these units, it is recommended that a size be selected that will give satisfactory correction at the ultimate rating of the plant. Since the initial rating may be less than this, a reduced corrective effect may be obtained by leaving out one or more of the capacitors. Thus if the ultimate capacity of a plant indicated the 18.2-kva unit be used, which employs four capacitors, a reduced corrective effect for the smaller capacity of the original plant could be secured by installing only two or three of the condensers. When the capacitance in series with a reactor is decreased, however, the resonance frequency rises, so that this reduction in the number of condensers can be carried out only to an extent that will not raise the resonance frequency beyond the desired limit. When the capacitance in series with a fixed reactor is changed by a factor p, the resonant frequency is changed inversely as the square root of p. Thus for three condensers instead of four, the resonance frequency would be $147/\sqrt{.75}$. For two condensers it would be $147/\sqrt{.50}$, and for one condenser it would be $147/\sqrt{.25}$. These give frequencies of 170, 212, and 294 cycles respectively, and all but the latter are satisfactory. Based on similar calculations, recommendations are made as to the permissible reductions of all the equipments available.

The effect of a capacitor installation on the voltage must also be determined before making recommendations. Although the voltage at the primary side of the transformers will vary slightly, depending on the system load, the chief variation of the bus voltage is due to the drop through the transformer with variations in load and power factor. With standard transformers, this drop at full load is about 5 per cent. As the load becomes capacitive rather than inductive, the drop becomes a rise. It would be as much as 5 per cent, however, only if the capacitor had as large a rating as the transformer and the motor load were substantially zero. In general the voltage can be taken as the ratio of the reactive kva of the capacitor to the kva rating of the transformer times 5 per cent. For the recommended installations, it varies up to about 2 per cent, and thus is not a serious matter.

These new condensers are built of aluminum foil and kraft paper, and use a non-inflammable liquid dielectric. Three of them are mounted in the bottom of a lead-lined metal container, and three terminals are brought out through porcelain bushings from the delta connections made inside the capacitor. The losses are small—about 3⅓ watts per kva—and tests indicate that the life of the condensers should be over twenty years. Three reactors are required for each three-phase capacitor. They consist of an inductively wound laminated core, and practically any inductance can be economically obtained. A typical installation is shown in Figure 2, with the capacitor below, and the three reactors above. Although this equipment was designed primarily for telephone power plants, it could economically be applied to any type of plant where power-factor correction with noise control is desired.

Identifying Cable Wires

By T. C. HENNEBERGER
Plant Products Development

IN TELEPHONE maintenance work, it is frequently necessary to identify a particular pair of wires out of some hundreds of pairs all alike that have been exposed by opening a cable at a splice. The 108A amplifier, already described in the RECORD,* was developed to simplify this work. Its operation requires that an audio-frequency tone be put on the desired pair at one of the terminals of the cable, and this tone is then "picked up" through capacitive induction to the blunt tip of a probe connected to the input of the amplifier. The tone is heard with a headset connected to the output of the amplifier.

In most cable-testing work, the pairs to be identified fall in the class of dead wires, and for this type of work the 108A amplifier is very satisfactory. Occasionally, however, it is necessary to identify wires without taking them out of service, and the 108A amplifier method cannot be used because the audio tone it places on the pair would interfere with normal telephone transmission. There has been developed therefore a new form of testing equipment that uses a tracing current so high in frequency as to be inaudible even though the line to which it is connected is in use for telephone purposes. The high-frequency identifying equipment comprises two portable test sets: the 72A test set for producing a 250-kilocycle current modulated by a frequency of 500 cycles, for use at one of the points between which identification is to be made; and the 71A test set, which includes a probe and loud speaker, for amplifying and then demodulating the pickup due to the tracing current so as to produce a 500-cycle note in the loud speaker. Views of these two sets are shown in Figure 1.

Consider, for instance, an underground toll cable such as the New York-Philadelphia G cable, and assume that a hole occurs in the sheath at some point between two manholes. This cable, like most toll cables, is

*January, 1939, p. 155.

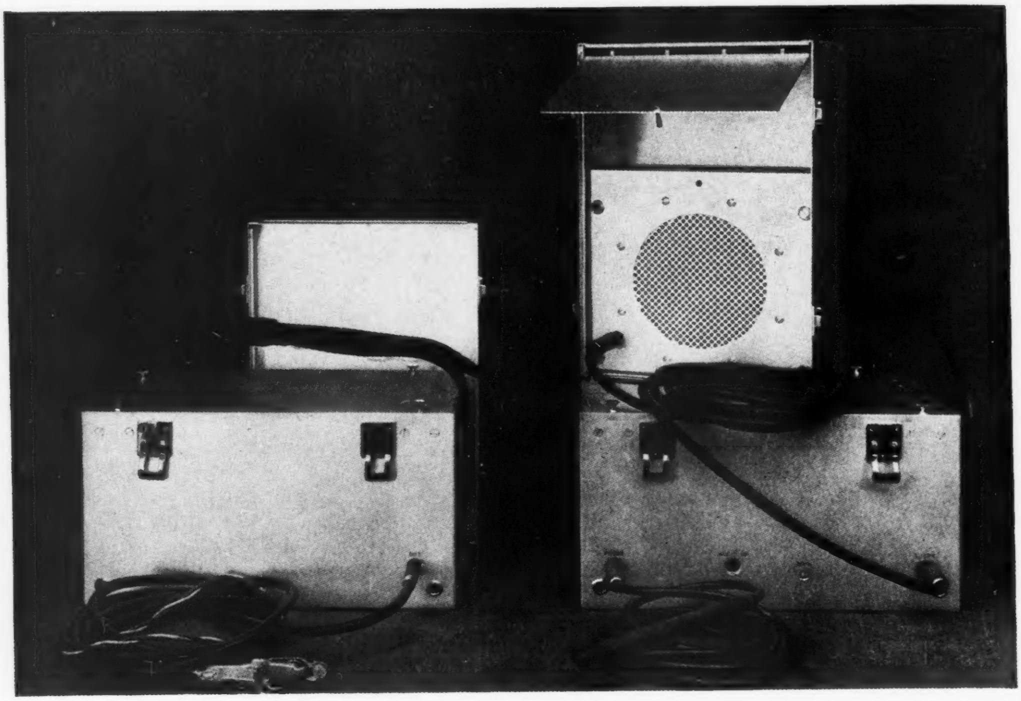


Fig. 1—Both the 71A and the 72A test sets are arranged in portable form

held under gas pressure, and gas leaking from the hole lowers the cable pressure and causes the operation of alarm equipment in the test rooms. Subsequent gas pressure measurements* are then made which locate the defective manhole section. During all of this locating work, the positive gas pressure at the hole prevents moisture from entering the cable so that the cable circuits are not affected. It is necessary, however, to replace the defective section because the hole is potentially dangerous to cable service as long as it remains.

The general process for clearing a trouble of this kind is to pull a length of replacing cable into a spare duct in the manhole section involved, and to transfer the circuits from the faulty to the replacing cable, one by one. The operation is called a working-section throw. All of the pairs of the replacing cable length are first identified between the manholes, by using standard apparatus such as the 108A amplifier, and the pairs are tagged at the two ends. A talking circuit is then established between the test board and each manhole, over a spare pair in the cable. After this preliminary work, the cableman at one manhole selects a wire in the faulty cable section and connects his high-frequency current source between the wire and ground. At the other manhole, another cableman searches among the wires with his probe. As he nears the proper wire with the probe, the 500-cycle note in the loudspeaker becomes stronger, and is a maximum when the probe is pressed against the wire. The schematic circuit arrangement is shown in Figure 2.

Having thus identified a wire, the cableman at each manhole selects the predetermined replacing wire, and splices it in parallel with the identified wire, so that temporarily the tele-

*Record, *March*, 1934, *p.* 214.

phone circuit is in both cables. Then the wire in the faulty cable is cut at each manhole, leaving the circuit through the replacing cable.

The highest frequency employed for normal transmission currents on cables is about sixty kilocycles, used for K carrier telephone circuits, although on toll entrance cables and short intermediate cables associated with the open-wire J carrier telephone system, 143 kc may be used. The 250 kilocycles of the identifying current is well above these transmission frequencies, and causes no interference with any circuits in the cable, although certain simple precautions have to be taken to avoid overloading the repeaters in those cases where carrier channels are employed.

The probe of the high-frequency 71A test set differs from the capacitive probe of the 108A amplifier in that it is slightly larger and contains in its tip a tiny coil having many turns of fine wire. The pickup is obtained both from the magnetic coupling between the turns of the coil and the cable wire and the capacitive coupling between the coil as a whole and the wire. This arrangement is needed because with a high-frequency tracing current, standing waves are sometimes produced on the wire being identified, particularly if the wire is loaded, and at some points the current may be relatively large compared to the voltage and at other points the reverse is true. The proportions of the probe are such that approximately equal pickups are secured for any relative strength of magnetic and capacitive effects that are encountered.

A loud speaker is used rather than a head receiver to give the cableman at the identifying point greater freedom of action, and because this method of listening is less tiring over

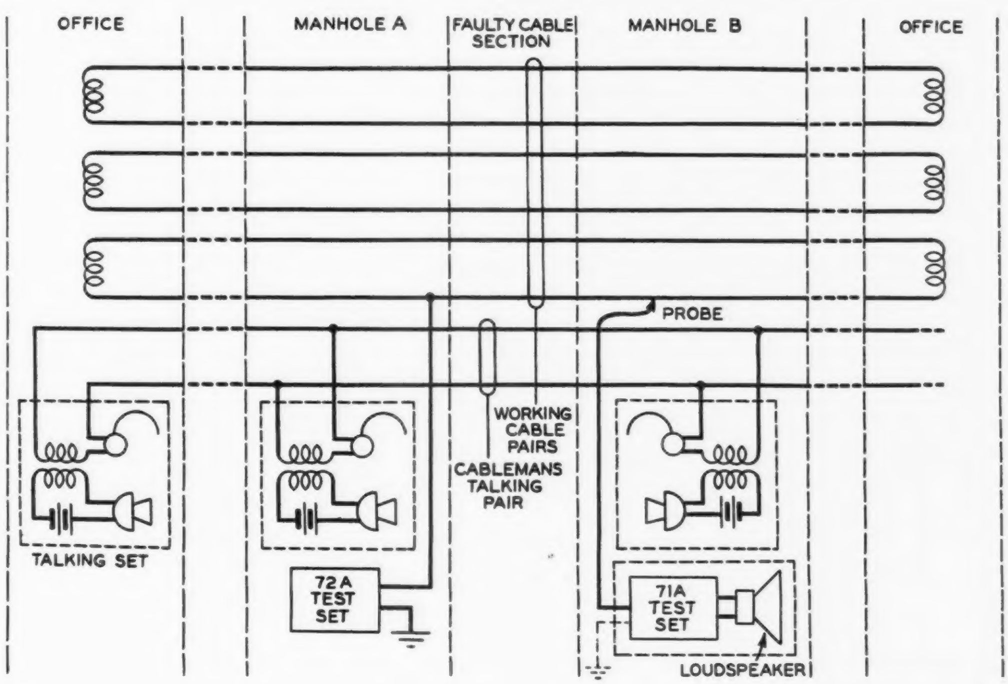


Fig. 2—Schematic representation of the method of using the high-frequency identifying equipment for identifying cable pairs with the 71A and 72A test sets

the several hours during which he is engaged in the identifying work.

Use of the 71A and 72A test sets results in a considerable decrease in testing time and expense over methods previously used for making working-section throws, with which it was necessary to reroute or "turn down" working circuits, one group after another, so as to permit the use of an audio-frequency identifying tone. The high-frequency identifying method, however, does not replace the 108A amplifier method, since it is applicable only over short distances, such as several manhole sections, because of the large attenuation of the line at the high frequencies.

The use of the test sets has been described here with particular reference to a fault caused by a sheath break in an underground toll cable. The sets are applicable also to cable transfers made necessary by other causes on both underground and aerial toll and exchange cables.

To provide for changes of the loudness of buzzers in private branch exchanges, this adjustable buzzer has been developed. By turning the knob the attendant can change the stroke of its armature and thus vary the volume of sound radiated. It operates on ringing current

Contributors to this Issue

D. M. Terry received the B.E.E. degree from Ohio State University in 1920, and at once joined the Technical Staff of the Laboratories. Here he was first associated with the Research Department, where he worked on fundamental carrier research and on the development of picture transmission. He was in charge of the transmitting apparatus in Cleveland for the first public demonstration of this system in 1924. Two years later he transferred to the toll group of the Systems Department. His work here has been chiefly on the development of automatic control of transmission level for carrier telephone lines.

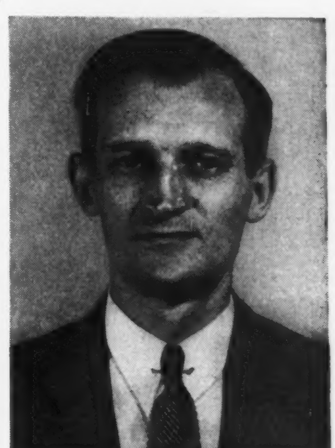
T. C. Henneberger was graduated from Lehigh University in 1921 with the degree of Electrical Engineer. For the following thirteen years he was a member of the Department of Development and Research of the A. T. and T., and was engaged in work on outside plant construction and maintenance problems. Since his transfer to the Laboratories in 1934 he has continued in the same line of work, and is at present in charge of a group handling the development of electrical apparatus for outside plant use.

George Wascheck received the degree of A.B. from Columbia University in 1924 and E.E. from the Columbia Engineering School in 1926. After spending one year as instructor in the Columbia Engineering School, he joined the Department of Development and Research of the A. T. and T. in 1927, where he was engaged chiefly in inductive coördination work on low-frequency induction between power and telephone lines. Since 1933 he has continued studies along the same lines with the Laboratories. These involve specific problems of earth-return coupling between power and communication circuits, the mitigation of induction effects by shielding due to shield wires, cable sheaths and tape-armoring; also the investigation of earth resistivities at various locations throughout the country.

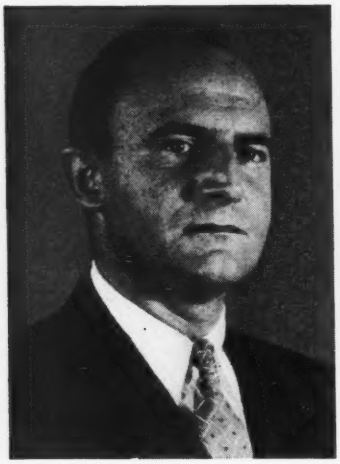
After discharge from the U. S. Army in 1918, L. J. Purgett returned to Purdue, receiving the degree of B.S. in Ch.E. in

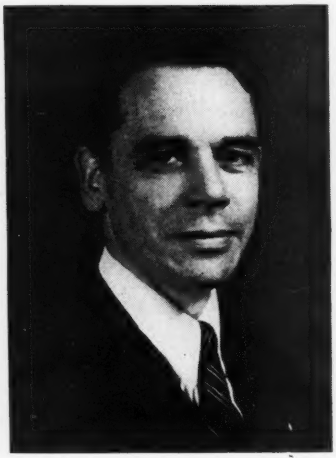
D. M. Terry

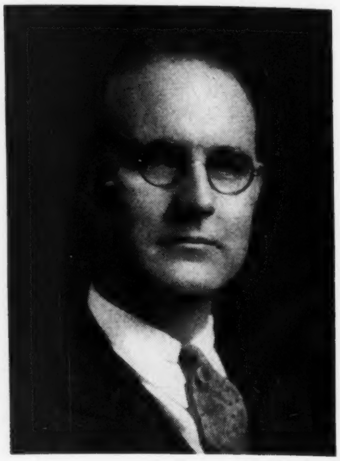
T. C. Henneberger



George Wascheck







L. J. Purgett *H. L. Mueller* *M. T. Dow*

1920, and the degree of Ch.E. in 1940. He spent a year with the Aluminum Company of America and a year with the William A. Baehr Organization, Consulting Engineers, and joined the Western Electric Company at Chicago in 1922. Until 1928 he was concerned with the engineering, manufacture, and installation of telephone central-office equipment. At that time he transferred to the Bell Telephone Laboratories, where he has since been engaged in the development and design of power supply and other equipment for central offices.

H. L. Mueller joined the Installation Department of the Western Electric Company in April, 1913, after various activities in commercial power and railroad work. From 1914 to 1918 he attended Pennsylvania State College, receiving the B.S. degree. Commissioned a Second Lieutenant in the United States Army, he served as Personnel Adjutant of the 152nd Depot Brigade until October, 1919, when he joined the Engineering Department of the Western Electric Company. He has since been identified with the power development group, supervising power plant standardization for local central offices from 1928 to 1932. In the latter year he became associated with power apparatus development, and entered the evening courses at Columbia University, receiving the M.S. degree in 1934. At present he is supervising the developments on storage batteries and control apparatus for power plants.

M. T. Dow was graduated from Ottawa University, Kansas, in 1917 with the B.S. degree. He received a Master's degree in Physics at the University of Pennsylvania in 1921. For several years Mr. Dow was an instructor at M.I.T. and Harvard University while doing graduate work there. After two summers with the Department of Development and Research of the A. T. and T., he joined that Department in 1929 and for six years worked on inductive coördination problems with the Joint Subcommittees of the Bell System and Edison Electric Institute. In this connection he developed methods of measuring the influence of power lines and of calculating noise in exposed telephone lines. Since 1933 Mr. Dow has been concerned with noise studies in connection with carrier telephone systems and open-wire telephone lines. In 1934, with the D and R, he transferred to the Laboratories.